A STUDY OF THE ACTUAL AND POTENTIAL USES OF INDUSTRIAL ENGINEERING IN A DEVELOPING ECONOMY: COSTA RICA

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A STUDY OF THE ACTUAL AND POTENTIAL USES OF INDUSTRIAL ENGINEERING IN A DEVELOPING ECONOMY: COSTA RICA

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To my Mother
To the Memory of my Father
To Carol

To all those persons who had helped me and inspired me to reach this goal.

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SUMMARY

This research has been aimed at determining the uses and needs for Industrial Engineering in a developing economy: Costa Rica. The answers to the following questions were considered: 1) What operational problems that may call for Industrial Engineering are being experienced by Costa Rican industries?, 2) What specific needs for Industrial Engineering applications arise from these problems?, 3) How are these needs presently being met?, 4) What can be done to meet these needs more effectively?, and 5) How does a developing economy (Costa Rica) utilize Industrial Engineering expertise as compared to a developed industrial system (State of Georgia, U.S.A.).

The necessary data to answer these questions was collected by means of two questionnaire surveys conducted among manufacturing firms in Georgia and Costa Rica. Confirmation, interpretation and expansion of Costa Rican survey results were made possible by the detailed investigation of fourteen individual firms which were representative of the Costa Rican responding group.

Based on the research data, it was concluded that: 1) there is a need among Costa Rican industries for Industrial Engineering services, 2) the country's manufacturing sector is not utilizing this professional service to the extent that the industrial needs seem to require, 3) for the most part, the existing industrial problem in Costa Rican industries call for basic and traditional Industrial Engineering applications rather than modern and sophisticated quantitative techniques, 4) a large

portion of the country's manufacturing firms do not use the services of Industrial Engineers not because they do not meet then but due to economical reasons or lack of management knowledge concerning Industrial Engineering practice, and 5) Georgia industries not only use Industrial Engineering services to a larger extent than similar Costa Rican industries, but also they apply these services more effectively.

Based on the research findings, this study provides recommendations for the improvement of Industrial Engineering practice in Costa Rican industries.

CHAPTER I

INTRODUCTION

In the past few years there has been much controversy concerning the appropriate role of the Industrial Engineer in developing countries (1).

Research studies have shown that the Industrial Engineering profession has a considerable contribution to make to the industrial development of these nations if only its practitioners maintain their awareness toward the objectives that pertain to industrialization and are able to adapt their professional background to the needs of the developing industries.

Since Costa Rica meets the requirements of a "developing economy" as described by Belshaw (27) and Meir (28), it is felt that a study of Industrial Engineering applications in the manufacturing sector of the country may provide the proper basis for determining the needs for this professional service to the industry and at the same time, may help to identify the type of industrial Engineering methodology required to cope with the problems of developing industries.

It is the purpose of this research to explore those operational areas within the Costa Rican manufacturing sector which may benefit from Industrial Engineering expertise. In doing so, this study attempts to determine how Industrial Engineering services are being applied in Costa Rican industries and how they should be used as a means to achieve more

efficiently the process of industrial development.

Statement and Importance of the Problem

For the past fifteen years, Costa Rica has experienced a rate of industrial development far greater than any previous period (3).

This industrial growth has given birth to a new type of industrial organization with more sophisticated technologies, larger production capacity and higher operational complexity. With the introduction of new technologies and production methods, a large portion of the Costa Rican manufacturing sector has been experiencing many of the common problems typical of large manufacturing enterprises. Furthermore, traditional methodology has proved to be ineffective in coping with these types of problems. As a result, a great need has arisen in the country for professional and technically oriented personnel capable of dealing with the operational and technological difficulties of the new industrial organization.

Even though the country's industry has been able to overcome a number of handicaps in industrial development, if the manufacturing sector is to continue growing at the pace of the past fifteen years, attention must be more sharply focused on those operational and technological problems affecting the industry today. In examining the possibility that a large majority of these problems could be solved through Industrial Engineering applications, it is significant to consider the conditions and respects in which Industrial Engineering concepts could be applied to the needs of industry. More specifically, an investigation must be made to determine: (a) those problem areas in the industry that call for Industrial

Engineering expertise, (b) the actual and potential uses of this professional resource in the solution of industrial problems, (c) the types of methodologies necessary to meet the needs of the developing industries, and (d) the possible ways of improving and strengthening Industrial Engineering practice as a means of achieving the goals of industrialization more efficiently.

Objectives of the Study

Before an effective analysis can be done on the actual and potential uses of Industrial Engineering concepts in Costa Rican industries, a better understanding is needed of those operational problems that are encountered in the industry itself. Furthermore, it may prove beneficial (for comparison purposes) to analyze how an industrial system (State of Georgia, U.S.A.) with wide availability of Industrial Engineers,[1] has utilized this professional resource in attempting to solve its manufacturing and organizational problems.

It is the primary objective of this research to provide a survey study that could be useful to Costa Rican industrial managers in evaluating their needs for Industrial Engineering services. More specifically, this research seeks to provide objective and meaningful answers to the following questions:

1. To what extent are Industrial Engineering services being used in Costa Rican industries as compared to industries with similar characteristics in the State of Georgia (U.S.A.)?

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[1] Georgia Department of Labor Security Agency, Industries and Occupations - 1975, Atlanta, Georgia, 1975.

2. In what specific functional areas do Industrial Engineers in Costa Rican industries devote their attention, as compared to those Georgia industries with similar characteristics?

3. Which, if any, organizational functions that call for Industrial Engineering expertise are actually perceived by Costa Rican managers as significant problem areas in their organization?

4. In those companies where Industrial Engineering services are not being used, what are some of the most important managerial reasons for not utilizing this professional resource?

5. What are some of the specific ways of broadening and strengthening Industrial Engineering practice in Costa Rica, in view of existing industrial needs?

Scope and Limitations

The scope of this research is restricted to the study of industries in Costa Rica and the State of Georgia (U.S.A.). Participating companies were chosen from among those with 50 or more employees and in one of the following industry groups:

- Textiles
- Food and Kindred Products
- Plastic and Metal Industries
- Chemical and Allied Products
- Miscellaneous Manufacturing Enterprises.

The above restrictions were purposely applied in order that attention may be more sharply focused on those industrial groups that constituted the larger portions of Costa Rican manufacturing sector.

Due to the survey methodology used in this study, the results obtained were subject to the degree of validity and reliability of the

data gathered. The effect of these factors on the final results is discussed in more detail in the methodology portion of this report (Chapter III).

The number of companies selected for the survey was limited to 100 firms in Costa Rica and 100 in the State of Georgia. Although these two groups are small when compared to the total industrial population in both locations, it was felt that this number would provide a representative cross-section of the industry from which to draw meaningful conclusions.

In addition to the written survey questionnaire, fourteen participants of the Costa Rican sample were investigated in more detail through personal visits and interviews. Five of these firms which were representative of the Costa Rican participating group in terms of industrial classification, size and types of problems were chosen for case history analysis. The operational and administrative procedures of each of these companies were evaluated in order to develop information which could be helpful in interpreting and verifying the survey results.

This research was primarily conducted for exploratory purposes. Although comparison is to be made among variables, the use of survey methodology, rather than controlled experimentation prevents conclusions concerning the cause and effect of any relationship discussed. In addition, the quantity and nature of the data collected precluded test for statistical significance of these relationships. Furthermore, the study was designed to gather descriptive information concerning the application of Industrial Engineering concepts in Costa Rica and makes no attempt to prove any causal relationship.

Definitions

Industrial Engineering functions used in this study were developed from the definition of "Industrial Engineer" in the Directory of Occupational Titles (2). In designing the questionnaire forms, the following list of Industrial Engineering functions was included:

Production cost analysis.
Production planning and forecasting.
Design of production processes.
Labor cost and performance evaluation.
Manpower resource allocation.
Labor training programs.
Plant facilities and layout.
Storage facilities design.
Expansion feasibility studies.
Design of safety programs.
Preventive maintenance programs.
Inventory control policies.
Quality control policies.
Transportation and distribution systems.
Scheduling and dispatching.
Cost reduction studies.
Work simplification studies.
Production capability analysis.

Industrial classifications used in the research were based on five major groups of industries defined as follows:

Textiles: This group includes establishments engaged in the production of textile mill products such as fabrics and yarns plus apparel and other finished products made from fabrics and similar materials.

Food and Kindred Products: Firms processing or manufacturing foods and beverages for human consumption and certain related products.

Chemical and Allied Products: Industries producing chemicals and establishments manufacturing products by predominantly chemical processes.

Metal and Plastic Industries: Companies engaged in the smelting

and refining of metals, and manufacturing of other basic metallic products. This group also includes firms involved in the molding of primary plastic and miscellaneous finished plastic products.

Miscellaneous Manufacturing Enterprises: This group includes industries engaged in manufacturing products not classified in any of the above groups. A significant portion of companies falling into this category were part of the electronic industry.

Research Approach

Due to the fact that a consideration of the problems of the industry would be impractical without the participation of those who are best acquainted with the problems, this research is based on management's response (Costa Rican and Georgia managers) to a questionnaire designed for the investigation of Industrial Engineering practices in the manufacturing sector. One hundred industrial firms in Costa Rica and one hundred in the State of Georgia were surveyed. The participants were selected on the basis of employment size and type of goods produced. To assure equal participation of every industrial group, approximately the same number of questionnaires were sent to each group investigated.

Each company was asked to answer a number of questions designed to: (a) collect information concerning problem areas that could be analyzed and/or solved through Industrial Engineering techniques, (b) show the actual utilization of Industrial Engineering concepts and the type of personnel responsible for their application, (c) establish, in cases where Industrial Engineering services were not being used, the most important reasons for not utilizing this professional resource, (d) collect

information concerning the employment distribution of Industrial Engineers among the different manufacturing sectors, and (e) obtain the reactions and opinions of Costa Rican managers concerning a scheme to improve Industrial Engineering practice in Costa Rican industry.

While the questionnaire responses provided much useful data, it was felt that a more detailed investigation of a group of industries in Costa Rica would be helpful in interpreting and verifying the survey results. Personal observation of the operational procedures of fourteen firms which were representative of the group investigated, not only served to clarify some of the survey findings, but also to confirm many of the survey results.

Although the approach used in this study is directed only to the analysis of Costa Rican industries, the conclusions and findings (when properly qualified) may prove to be beneficial to other economies in a similar process of industrial development.

CHAPTER II

LITERATURE SURVEY

Industrial Engineering emerged as a separate discipline in the late nineteenth and early twentieth centuries. However, it was not until the post World War II period that the profession achieved its maturity and became recognized as an effective means of coping with some of the operational and organizational problems of industry.

A large amount of literature exists today concerning the usefulness of Industrial Engineering not only in manufacturing but also in non-manufacturing enterprises. While most of the articles in the literature deal with situations characteristic of highly developed economies, some of the more recent papers discuss the needs, uses and necessary adaptations of Industrial Engineering activities for those countries in the process of development.

In this chapter, it is the intention to provide the reader with a review of the research that has been done in the following areas:

- The Industrial Engineering profession; its development, importance and areas of application in a developed society (The U.S.A.).
- Industrial Engineering in developing economies; its needs, adaptations and implementation problems.
- The characteristics that make Costa Rica a typical example of a developing economy.

It is hoped that this study will introduce some concepts that will aid in the investigation of Industrial Engineering practice in developing nations.

The Industrial Engineering Profession

> Industrial Engineering is concerned with the design, improvement and installation of integrated systems of men, materials, and equipment.
>
> It draws upon specialized knowledge and skill in the mathematical, physical, and social sciences, together with the principles and methods of engineering analysis and design, to specify, predict, and evaluate the results to be obtained from such systems. (4)

From the days of Taylor, there has been considerable development in the field of Industrial Engineering with regard to concepts, techniques and areas of application. Originally concerned largely with the basic design of manufacturing plants, methods improvement, work measurement, the design and evaluation of wage payment systems, cost control and the like -- Industrial Engineering methodology has become, during recent years, more quantitative by the use of methods in operations research, mathematical programming and statistical analysis.

Today, the complexity of industrial and business operations demands a new type of Industrial Engineer whom Wilson (5) describes as no longer a time study man but a university trained engineer with an array of analytical tools, largely based on mathematical methods and supported by a considerable amount of economics and behavioral sciences. The Directory of Occupational Titles (2) outlines in more detail and attributes of the modern Industrial Engineering in the following terms:

> The Industrial Engineer is the practitioner that performs a variety of engineering work in planning and overseeing utilization of production facilities or other subdivisions of industrial establishment.
>
> He is the person that plans equipment layout, work flow and accident prevention measures to maintain efficient and safe utilization of production facilities.
>
> He plans and oversees work studies and training programs to promote efficient manpower utilization.
>
> He develops and oversees, quality control, cost control, inventory control and production standards. (2)

As for the importance of the profession, Rathe (6) stresses that its wide recognition lies not only in the effectiveness of its procedures but also on the fact that its applications encompass literally every type of human behavior. Furthermore, the significance of the profession is emphasized by the employment figures of its practitioners, Geis (7) shows that the use of Industrial Engineers has increased approximately 100 per cent over each of the last two decades (1952-1972), while the U. S. Labor Department (8) projected the employment of Industrial Engineers for 1985 as 190,000 or a 53.5% increase over 1975. This is the highest projected percentage increase for any of the engineering disciplines. Concerning the level of utilization of the profession among the various sectors of the U. S. Economy, Geis (7) shows that a remarkable increase has taken place in the government and service sectors with a relatively constant utilization rate in the manufacturing industries.

On the basis of the existing literature, it will be meaningful to illustrate the participation of Industrial Engineers in the main three sectors of the U. S. Economy: (a) government, (b) manufacturing industries, and (c) service industries.

Government

The participation of the profession in this sector dates back to Morris L. Cooke and his scientific management efforts in government (9). In the early 1960's, Mundel (10) introduced the Industrial Engineering team approach in the study of the effectiveness and efficiency of governmental agencies and in formulating recommendations for management practice.

Today, this engineering discipline is not only found in the Federal Government but also in State and Local Governments. Luftig and Friedman (11) describe some of the more common areas of Industrial Engineering application in government as follows:

Work simplification studies
Methods Improvement
Organizational Planning
Budgetary analysis
Facilities planning and utilization
Urban planning and development
Management procedures
PERT
Operations Research

In addition, Geis (7) points out how the U. S. Postal Service (an agency of the Federal Government), has largely utilized Industrial Engineering expertise in improving materials handling programs and manpower allocation.

In 1972 the governmental sector was employing 7% of the total available Industrial Engineers in the country as compared to only 3% in 1966, and it is expected that as the government grows in size and complexity, the need for Industrial Engineers will grow with it (Geis 7).

Manufacturing Industries

It is in this economic sector that the profession has had its longest and most meaningful participation. At the present time, 70 per cent of the total available Industrial Engineers in the United States are dedicated (in one way of another) to manufacturing activities (Geis 7). According to Malcolm (12), Industrial Engineering is being applied in this sector "as a means to bring economics, costing, human factors and engineering systems to a total effort -- an effort directed to optimize the use of physical and human resources in the achievement of

production objectives.

As a staff member of the organization, Smith (13) points out that the Industrial Engineer seems to be the professional that brings a business sense of reality to the other engineers, by straddling the vast gap between the practical manager and the development engineer. Furthermore, the literature, (e.g. 14, 15) shows that in more recent years the role of the Industrial Engineer in manufacturing enterprises has not been limited to engineering practice but has expanded to cover some of the duties of management positions.

Some of the most important functions being assigned to this practitioner in the manufacturing sector, are identified as follows (16):

Manufacturing Methods
Product Engineering
Product Line Development
Equipment Specification
Facilities Planning
Cost Control Development
Cost Reduction Programs
Wage Administration
Labor Incentive Programs
Labor Cost Analysis
Labor Relations
Quality Standards
Inventory Control Methods
Materials Handling Procedures
Preventive Maintenance Programs
Methods Improvement
Expansion Proposals
Production Standards
Production Scheduling and Forecasting

Service Industries

The service industries have shown the largest increase in the employment of Industrial Engineers during the last few years. Today, 21% of the professional force is participating in this sector as compared to 4% in 1966 (Geis 7). The fastest growing utilization rate of Industrial

Engineers is found in the transportation and health care systems. Aft (17) outlines how, at the present time, many medium and large hospitals in the United States are using Industrial Engineering techniques to improve their work methods and procedures in achieving higher operational efficiency and reducing organizational costs. More specifically, Staib (18), describes the growth of Industrial Engineering practice in Metropolitan New York Hospitals in such areas as:

Improving Public Services
Resources and Facilities Utilization
Cost Reduction in Patient Care
Manpower Allocation
Development of Nurse Staffing and Scheduling

With regard to transportation and distribution systems, Elias (7) comments on how the airline, railroad and trucking industries have taken advantage of Industrial Engineering techniques to investigate methods and procedures to promote better and more efficient customer service and to reduce their operational costs.

Other areas are described in the literature as utilizing Industrial Engineering concepts to a lesser degree. Some of these areas are related to agricultural activities, computer services, retail stores and public libraries.

The challenge of the Industrial Engineering profession naturally increases as industry and business size increases in complexity. The need for scientific management and safety engineering in reducing cost and increasing productivity and newer areas of work such as noise, air and pollution control, appear to be some of the most important challenges for Industrial Engineers in the next twenty five years (19).

Industrial Engineering in Developing Economies

> In the developing countries, where a 90 per cent growth rate is expected by the year 2000, the Industrial Engineer will be needed to train people, to plan the most efficient industrial and agricultural systems and to manage the projects.
> It may be that fully one half of the Industrial Engineers required at that time in highly developed countries will be needed in the not so developed nations (20).

During recent years, articles on the role of Industrial Engineering in developing economies have begun to appear more frequently in literature. Most writers (e.g., 21,22) seem to agree that the Industrial Engineering profession has a considerable contribution to make to the industrialization process in developing nations. However, lack of consistency exists among these authors as to the extent and type of Industrial Engineering methodology required to meet the needs of these economies.

Mendenhall (22) maintains that developing nations can benefit greatly from the use of Industrial Engineers as long as these professionals are able to adapt their educational background to fit the characteristics and needs of the developing industries. Furthermore, he believes, that because these countries are labor intensive economies by nature, the vital function of this profession is not meant to concentrate in modern quantitative techniques. Instead, traditional concepts of manpower development and training are needed.

On the other hand, Hofmeister (23) believes that a considerable change in Industrial Engineering methodology is not necessary when applied to developing nations. Throughout his experiences in working with these countries, Hofmeister concluded that when viewing the Industrial Engineering process in its totality, most of the techniques practiced in

developed societies are also applicable to developing economies and most differences in practice are a matter of degree rather than nature.

Beenhakker (24) tends to agree with Mendenhall (22) that Industrial Engineers in developing nations are faced with traditional types of problems more often than developed countries. Thus, there is the need for a more traditional approach in the solution of these problems. However, Beenhakker believes that more modern techniques can benefit the industrial development of these nations if the respective managerial forces are willing to accept innovations and use their young Industrial Engineers more efficiently.

Several examples of the establishment of this engineering discipline in developing economies are discussed in the literature, (e.g., 1, 10). Israel, as outlined by Dathon (26), represents perhaps the most meaningful case of hos Industrial Engineering practice can benefit a developing nation. Dathon describes how, during the past twenty years, Israel has taken advantage of these systems, new engineering methods and efficient manpower utilization. In addition, Industrial Engineers in Israel have participated in the improvement and design of production methods, production cost analysis, cost reduction studies, industrial relations problems and quality control programs.

Israel must be considered a very unique example among developing economies in regard to the application of Industrial Engineering concepts. Other countries with similar characteristics have not been so successful in implementing these concepts, for several important reasons outlined by Adulbhan (1) and Beenhakker (24) as:

Historical mistrust of new innovations
Conformation by tool-oriented managers to their own work habits rather than accepting new technologies.
Limited knowledge by management forces concerning Industrial Engineering practice.
Unawareness of the profession.
Lack of identification of problems calling for Industrial Engineering expertise.
Poor quality information.
Poor computer facilities.
Overeducated young engineers, and
Lack of national standards concerning the overall industrial development.

In the specific case of Costa Rica, there appears to be no existing literature in the field discussed. However, considering the country as a developing economy, the literature cited in previous paragraphs provides a useful basis for further study of Industrial Engineering applicability to economic development of Costa Rica.

Costa Rica as a Developing Economy

> Underdeveloped nations may be generally characterized by conditions of poverty, disease, illiteracy, rapid population growth and low level of industrialization.
> Those countries attempting to alleviate these conditions are referred to as developing nations. (22)

Today, no single definition for "developing economies" is entirely satisfactory. Nevertheless, it is possible to focus on some fundamental characteristics considered by economists to be essential for economic development. Belshaw (27) and Meier (28) outline some of these requirements as: (a) increase of real national income over a long period of time, (b) increase in per capita income simultaneously with a reduction in population growth rate, (c) establishment of health, education and social programs to improve living standards, (d) adaptation of capital, labor and technology to achieve economic independence, and (e) ability

to produce the necessary consumer goods to satisfy economic needs.

Costa Rica, one of the six Central American Nations, presents many of the characteristics described by Belshaw and Meir. With a population of nearly 2 million people, Costa Rica has experienced during the last twenty years (1954-1974), an increase in its Gross National Income of approximately 400 per cent accompanied by a steady increase in per capita income (29).

In the process of achieving economic independence, Costa Rica has emphasized its industrial development. Today, the country is capable, not only of producing most of the capital and consumer goods required to meet its economic needs, but also to export a large amount of them to foreign markets (29). The industrialization process has been the most important factor in the Costa Rican economic development. The contribution of the manufacturing sector to the country's economy has doubled during the last decade and at the present time over 40 per cent of the labor force is involved (in one way or another) in manufacturing activities (3). Table 1 shows the industrial growth that has taken place in the last fifteen years in terms of number of firms established and total capital invested. As it can be observed from the data in the table, in 1960 only 8 manufacturing companies with a capital of 6.9 million colones (1.1 million dollars, exchange rate 1970), were operating in the country. In 1973 a total of 855 companies with an investment of over a billion colones made up the country's industrial sector. Furthermore, the estimated investment involved in expansion projects for established manufacturing firms between 1973-1975 surpassed 500 million colones (3).

Table 1. Structure of the Costa Rican Industrial Sector (1960-1973)

Year	Number of New Companies	Investment (millions of colones)
1960	8	6.9
1961	33	104.2
1962	46	77.2
1963	75	39.8
1964	81	122.6
1965	97	166.1
1966	139	190.9
1967	73	35.3
1968	73	52.4
1969	36	50.7
1970	27	23.8
1971	47	31.9
1972	69	84.4
1973	51	36.6
TOTAL	855	1,042.8

Camara de Industrias de Costa Rica, Directorio Industrial 1974. Page 12. San Jose, Costa Rica. (3)

In the fields of education and health, Costa Rica, not only has one of the highest literacy rates in the American continent but also the best health care program in the Central American area (30).

Although it can not be said at this time that Costa Rica has achieved complete economic independence, the economic behavior of the past fifteen years certainly indicates that the country meets most of the requirements of a "developing economy" as stated by Belshaw (27) and Meier (28).

Discussion of Literature Survey

The literature survey was valuable in pointing out that the Industrial Engineering profession has a considerable contribution to make to the industrialization process of developing nations. Whether modern or traditional methodology is more apt to fulfill the needs of these economies, is a question that can not be answered in general terms through the literature and must be analyzed on an individual basis for each country.

Nevertheless, the following aspects were suggested throughout the literature as meaningful for consideration for any study of Industrial Engineering practice within the manufacturing sector of developing nations:

- Current role of the Industrial Engineering profession within the country's industry.
- Type of problems in the industry that call for Industrial Engineering expertise.
- Type of Industrial Engineering methodology required to meet the needs of the country's industry.
- Methods of improving Industrial Engineering practice to accelerate the nation's industrial development.

Chapter IV and V of this report are devoted to analysis of each of these aspects for the specific case of Costa Rica, based on research conducted in a number of the country's manufacturing establishments.

CHAPTER III

RESEARCH METHODOLOGY

The research phase of this study consisted of two questionnaire surveys conducted among manufacturing firms in Costa Rica and the State of Georgia (U.S.A.). In addition, a more detailed investigation was done (through personal interviews and plant visits) in fourteen companies which were representative of the Costa Rican survey sample.

The Costa Rican survey was designed to study the actual and potential uses and needs of Industrial Engineering within the country's manufacturing sector. The Georgia survey, on the other hand, was intended to collect basic data that could be used to illustrate how an industrial system with large resources in the field of Industrial Engineering utilizes this professional resource in the solution of manufacturing problems. More specifically, the Georgia survey was expected to provide information with regard to: (a) the use of Industrial Engineering services in the manufacturing sector, and (b) the type of functional activities in which the industries were or had used the expertise of Industrial Engineers.

Description of Survey Procedures and Questionnaires

To insure the collection of reliable responses and to encourage the participation of as many firms as possible, considerable care was taken in designing the questionnaire forms and in drafting the cover letters used in the surveys. Copies of both, questionnaire forms and

cover letters are included in Appendices A and B of this report.

Clarity, brevity and completeness were the criteria used in developing questionnaire forms. Identification questions were limited to those which permitted the analysis of responses by industry type and company size (number of employees). Multiple choice and check list answers were used where possible to make it more convenient for the respondents to complete the forms and to facilitate the tabulation and classification of responses.

The first portion of the questionnaires (items 1 to 8 in the Costa Rican form and 1 to 10 in the Georgia survey) was designed to gather information as to the respondent's identification (type of industry and number of employees) and its use of Industrial Engineering services. The second portion of the questionnaires (item 12 in the Costa Rican form and 11 in the Georgia survey) was intended to accumulate comprehensive data concerning the type of functional activities assigned to Industrial Engineers in those companies using the services of these practitioners. Item 13 of the Costa Rican questionnaire inquired into those operational and organizational areas (that call for Industrial Engineering expertise) which were perceived by company officials as significant problems in their firms. In addition, three questions were included in the Costa Rican questionnaire for the purpose of obtaining management opinions and reactions concerning the establishment of a non-profit consulting office to assist the industries in activities related to Industrial Engineering.

Selection of Firms Surveyed

Participating firms were selected from among the following industrial

groups: (a) Textiles, (b) Food and Kindred Products, (c) Plastic and Metal Industries, (d) Chemical and Allied Products, and (e) Miscellaneous Manufacturing Enterprises. These industrial classification was used because these groups were found to constitute the largest portion of the Costa Rican manufacturing sector (3). A minimum employment of 100 persons was set for industries surveyed in Georgia because it was felt that firms above 100 employees were more apt to be using Industrial Engineering services (due to their size and requirements for specialized personnel) and thus could provide the necessary information for a study of this nature. In the case of Costa Rican companies, no employment data was available prior to conducting the survey, so the selection of firms was independent of company size. A minimum employment level of 50 persons was a random result of the outcome of the survey.

The final survey list were compiled from the Georgia Manufacturing Directory (32) and the Directorio Industrial de Costa Rica (3). These lists contained names and addresses of 100 Costa Rican firms and 100 companies in the State of Georgia. In determining the size of the mailing lists, it was felt that the number and distribution of companies chosen would provide a representative cross-section of industry from which to draw meaningful conclusions.

Tabulation of Data

As completed questionnaires were received, the responding companies were classified by type of industry, company size, and on the stated use or non-use of Industrial Engineering services.

A summary of tabulated answers to all items of the questionnaires

is presented in Tables 1 to 12 of Appendix A and Tables 1 to 11 of Appendix B of this report. Answers to item 3 of both questionnaires (concerning company's sales figures) are not included in the analysis of results since a large number of the participants considered this confidential information. A more detailed analysis and discussion of survey results are founded in Chapters IV and V of this study.

Case Histories

One of the primary purposes for the detailed investigation of a number of representative Costa Rican firms during the course of the research phase was to develop information which would be helpful in interpreting some of the results of the comprehensive questionnaire survey. The case history analysis served not only to clarify certain survey findings, but also to confirm many of the survey results. Fourteen case history companies were chosen after questionnaires were received, and a special effort was made to choose firms that were representative of the survey respondents and that were likely to be able to provide useful information in interpreting survey results. The management and operational procedures of these firms were analyzed through personal interviews and visits to the manufacturing plants. Five of these fourteen firms were selected for further discussion in this report (case history abstracts, Appendix C) because they provided the necessary information to clarify some questions that arose in the analysis of data. A summary of these investigations is included in the case history portion of Chapter IV.

Description of Survey Samples

As of June 1, 1975, questionnaires have been received from 148 respondents. Of this number, 70 questionnaires were from Costa Rican firms and 78 from companies in Georgia. Table 2 shows the percentage distribution of responses in terms of industry type and company size.

Discussion of Sampling Biases

Two types of sampling biases may have affected the results of this study: (a) errors due to biased source list, and (b) bias from non-respondents. The first of these biases is usually the result of a non-representative list of participants. In this research, every effort was made to compile survey lists which were representative of the industrial populations investigated. However, due to the lack of existing information concerning the internal structure of the industrial groups surveyed (total number of companies in each group), no attempt was made to prepare source lists in which the number of participants for each group was proportional to the total population of each industry type or size category. Furthermore, the limited number of firms that could be identified in Costa Rica in the textile industry and with employment level above 600, restricted the sample size in these two groups. The effect of a bias source list was significant in this research to the extent that it prevented any meaningful comparison of results among the major industrial groups investigated.

The second type of sampling bias (due to non-respondents) has generally the effect of overstating survey results. It is always dangerous to attempt to interpret the reasons for unreturned questionnaires, however,

Table 2. Distribution of Survey Responses

	Costa Rica		Georgia	
	Number	Percentage of Total Responses	Number	Percentage of Total Responses
1. DISTRIBUTION OF RESPONSES BY INDUSTRY TYPE				
Textiles	10	14.3	21	26.9
Food and Kindred Products	14	20.0	16	20.5
Plastic and Metal Industries	15	21.4	15	19.2
Chemical and Allied Products	17	24.3	15	19.2
Miscellaneous Manufacturing Enterprises	14	20.0	11	14.2
TOTAL	70	100.0	78	100.0
2. DISTRIBUTION OF RESPONSES BY COMPANY SIZE				
50 to 100 employees	16	22.9	N.A.	N.A.
100 to 200 employees	32	45.8	21	26.9
200 to 400 employees	12	17.0	27	34.3
400 to 600 employees	7	10.0	17	22.2
More than 600 employees	3	4.3	13	16.6
TOTAL	70	100.0	78	100.0

it seems logical in this case to assume that a firm that was unfamiliar with the Industrial Engineering profession would be more likely to not answer the questionnaire, than one which was familiar with it. This assumption was partially confirmed by the fact that groups of firms which showed high response rate were also the same which indicated that they were using or had used Industrial Engineering services (see Tables 3, 8, and 10). This means that the results obtained in the surveys, with regard to the overall use of Industrial Engineering assistance and utilization of Industrial Engineering expertise in different operational areas, may be overstated. In an actual situation, these figures may be smaller than those presented in this report.

Validity and Reliability of Results

Validity is the extent to which a survey is successful in measuring what it sets out to measure (33). While it is simple to provide a definition of validity to measure it in practice is exceedingly difficult.

The validity of the data collected in this study may have been affected by several factors. The first of these factors relates to the design of the questionnaire forms and the clear exposition and wording of the items included in the forms. In order to minimize this effect, questionnaires were reviewed, prior to conducting the surveys, by some of the academic advisors to the study who found them satisfactory as wording and exposition of questions were concerned. Nevertheless, in the analysis of data, the author felt that the validity of certain items (e.g., # 12 Costa Rican questionnaire) may have been affected due to the misinterpretation of questions by the respondents. The method of comparison

Table 3. Response Rate Analysis

1. TOTAL RESPONSE RATE

	Costa Rica			State of Georgia (U.S.A.)		
	Number of questionnaires mailed	Number of Responses	Response Rate	Number of questionnaires mailed	Number of Responses	Response Rate
2. RESPONSE RATE BY INDUSTRY TYPE						
Textiles	12	10	83.3	22	21	95.4
Food and Kindred Products	21	14	66.6	20	16	80.0
Plastic and Metal Industries	21	15	71.4	20	15	75.0
Chemical and Allied Products	21	17	80.9	20	15	75.0
Miscellaneous Manufacturing Enterprises	25	14	56.0	18	11	61.1
TOTAL	100	70	70.0	100	78	78.0
3. RESPONSE RATE BY COMPANY SIZE						
50 to 100 employees	20	16	80	N.A.	N.A.	N.A.
100 to 200 employees	40	32	80.0	25	21	84.0
200 to 400 employees	18	12	66.6	30	27	90.0
400 to 600 employees	16	7	41.2	25	17	68.0
More than 600 employees	6	3	50.0	20	13	65.0
TOTAL	100	70	70.0	100	78	78.0

of survey results with results obtained by interview techniques was used in testing the validity of the data gathered through item # 12 of the Costa Rican survey. Table 4 presents the results of this test. No testing procedure was applied to questions calling for factual answers. However, this type of question often shows high validity because of the specific nature of the information requested (33). Items requiring personal judgement are highly subjective by nature. Also, addressing the problem of validity for questions of judgement is difficult due to the lack of a criterion against which to compare the responses.

In summary, the validity of the data may have affected the results of the study to the extent that it is not possible to determine if the responses are fully representative of the actual uses and needs for Industrial Engineering applications among the industries investigated. Nevertheless, Table 5 shows that although the validity of some of the data may be questionable, the results are still valid enough to draw meaningful conclusions.

Reliability is the extent to which survey results repeat themselves independent of time, assuming no change in variables measured (34).

Only the test-retest method was used in testing the reliability of the data collected in this study. All other methods (odd-even comparison of questions and split ballot techniques) could not be applied to the results of the study because the questionnaire format did not meet the requirements for these testing procedures. The test-retest method was used in item 12 of the Costa Rican questionnaire. Fourteen participants in the survey were retested a month after their responses were

received. The answers to the questionnaire were compared with those of the retest to determine if they repeated themselves. With the exception of labor performance and accident prevention, the responses to all other functions proved to be highly reliable (Table 5).

Answers that were specific by nature were not tested, however, it is known that in most cases they are very reliable due to the type of responses required (34). The problem of reliability for items of judgement was not considered in this report.

With the exception of responses of judgement it can be concluded that the data gathered through these surveys appears to be reliable enough for the purposes of this research.

Table 4. Validity Test Results (Item 12, Costa Rican Questionnaire)

Functional Area	Percentage of Agreedable Answers	Validity Level (*)
Time Studies and Standards	93.0	Good
Expansion Feasibility Studies	100.0	Good
Materials Handling	86.0	Good
Scheduling and Dispatching	86.0	Good
Cost Reduction Studies	86.0	Good
Work Simplification Studies	94.0	Good
Production Standards	71.0	Acceptable
Manpower Allocation	71.0	Acceptable
Labour Incentive Programs	78.0	Acceptable
Plant Facilities and Layout	71.0	Acceptable
Storage Facilities Design	71.0	Acceptable
Accident Prevention	71.0	Acceptable
Preventive Maintenance Programs	78.0	Acceptable
Production Cost Analysis	57.0	Questionable
Production Planning and Forecasting	64.0	Questionable
Design of Production Processes	57.0	Questionable
Labour Performance and Cost	64.0	Questionable
Labour Training Programs	57.0	Questionable
Inventory Control	57.0	Questionable
Quality Control	64.0	Questionable

Testing Procedure: Comparison of survey results with results obtained by interview techniques.

Number of companies tested: Fourteen (14)

Criteria Used: Percentage of answers to the questionnaire that agreed with the surveyer evaluation

(*) Standards Set: 80% or more consistent answers---Good Validity---
70% to 80% consistent answers----Acceptable Validity-
50% to 70% consistent answers--Questionable Validity-

Table 5. Reliability Test Results (Item 12, Costa Rican Questionnaire)

Functional Area	Percentage of Answers that Repeated themselves	Reliability Level (*)
Production Cost Analysis	93.0	Good
Production Planning and Forecasting	86.0	Good
Design of Production Processes	86.0	Good
Production Standards	86.0	Good
Manpower Allocation	86.0	Good
Time Studies and Standards	100.0	Good
Labor Incentive Programs	93.0	Good
Plant Facilities and Layout	93.0	Good
Storage Facilities Design	93.0	Good
Expansion Feasibility Studies	100.0	Good
Preventive Maintenance Programs	86.0	Good
Inventory Control	86.0	Good
Quality Control	100.0	Good
Materials Handling	86.0	Good
Scheduling and Dispatching	100.0	Good
Work Simplification Studies	86.0	Good
Cost Reduction Studies	79.0	Acceptable
Labor Training Programs	79.0	Acceptable
Labor Performance and Cost	64.0	Questionable
Accident Prevention	64.0	Questionable

Testing Procedure: Test-retest method

Number of Companies Retested: Fourteen (14)

Criteria Used: Percentage of answers to the questionnaire that repeated themselves in retest

Standards Set: 80% or more repeated answers--Good Reliability--
70% to 80% repeated answers---Acceptable Reliability--
50% to 70% repeated answers---Questionable Reliability-

CHAPTER IV

DESCRIPTION AND DISCUSSION OF RESULTS

The questionnaire surveys conducted in the research phase of this study were designed for the purpose of collecting information that could be useful in fulfilling the following objectives of the study:

(1) To determine to what extent Industrial Engineering services are being used in Costa Rican industries as compared to industries with similar characteristics in the State of Georgia (U.S.A.).

(2) To identify those functional areas to which Industrial Engineers in Costa Rican industries are devoting their attention as compared to those Georgia industries with similar characteristics.

(3) To determine which, if any, organizational functions that call for Industrial Engineering expertise were recognized by Costa Rican managers as significant problem areas in their organizations.

(4) To identify, in those companies, that have never used Industrial Engineering services, what were some of the most important managerial reasons for not utilizing this professional resource.

A last objective of the study (To determine specific ways of broadening and strengthening Industrial Engineering practice in Costa Rican industries in view of their needs) will be the topic of discussion of Chapter V.

The first portion of this chapter is devoted to the presentation

and description of the data collected corresponding to each of those objectives listed. (In objectives 1 and 2, in addition to presenting and describing the data, comparison is made between the results of the Georgia and Costa Rican surveys.) Another section of the chapter provides further interpretation on some of the survey findings based on detailed investigations conducted in a number of Costa Rican manufacturing companies. The final portion of the chapter is devoted to the summary and discussion of research results. In each of the sections, the objectives are restated for easy reference.

Objective No. 1

The first objective of the study was to determine to what extent Industrial Engineering services were being used in Costa Rican industries as compared to industries with similar characteristics in the State of Georgia (U.S.A.).

In order to gather the necessary data for this analysis the participants in both surveys (Costa Rica and Georgia) were asked to indicate: (a) if they were employing Industrial Engineers on a full-time basis, (b) if they were using or had used consulting services in this professional field, and (c) if they were or had received Industrial Engineering assistance from corporate staffs. The responses to these questions were classified under three major categories: (a) companies with Industrial Engineering staffs, (b) companies using only consulting services and/or corporate assistance, and (c) companies that had never used Industrial Engineers. A summary of the tabulated answers for the Costa Rican and Georgia responses are presented in Tables 6 and 7 respectively. A more

detailed analysis of these responses by industry type and company size is shown in Tables 8, 9, 10 and 11.

Description of the Costa Rican Data

Of the 70 companies that responded to the Costa Rican survey, 38 or approximately 54 per cent, indicated that they had used or were using Industrial Engineering assistance. Of this number, 20 reported current employment of Industrial Engineers on a full time basis. These figures indicate that almost half (45.7%) of the respondents had never used this professional resource and less than one third (28.6%) of the companies were using these services on a day to day basis by means of Industrial Engineering staffs. A more detailed analysis of the distribution of services by industry type (Table 8) revealed that the textile and Chemical industries were utilizing Industrial Engineering assistance at a higher rate than any other industrial group investigated, whereas, the food industry showed the lowest utilization rate. An analysis of the results by company size (Table 10) indicated that in each progressively larger size category, the relative use of Industrial Engineering assistance increased. (One exception occurred in firms with 400 to 600 employees, however, this may not be significant considering the small number of responses within this group.) It was also interesting to notice that the largest use of consulting services took place in the three smaller size categories and no firm above 400 employees reported to have used consulting assistance.

Comparison of the Use of Industrial Engineering Services between Costa Rican and Georgia Industries

A comparison of the overall results (concerning the use of

Industrial Engineering services -- Tables 6 and 7) of the Costa Rican and Georgia surveys revealed that industries in the State of Georgia were using this professional to a larger extent than their Costa Rican counterparts. While almost 90 percent of the Georgia respondents indicated that they were using or had used the services of Industrial Engineers, only 54 per cent of the Costa Rican participants acknowledged to have used similar services. In breaking down these percentages according to the type of services used (consulting or full time staffs), it was observed that Georgia manufacturers were more inclined to use Industrial Engineers on a full time basis than to use consulting assistance. This was not the case in Costa Rican industries where almost half of the companies using Industrial Engineering services were doing it by means of consulting assistance.

A comparison of results by type of industry (Tables 8 and 9) shows that in every major industrial group investigated, the usage of Industrial Engineering services was quite higher for those industries in Georgia than for similar industries in Costa Rica. Furthermore, the textile and chemical industries in both manufacturing systems accounted for the largest utilization rate of this professional resource, however, it must be pointed out that within these two groups, the Costa Rican firms were using, for the most part, consulting services, while the Georgia companies were depending mostly on their Industrial Engineering staffs. The same observation applies to all other major industrial groups surveyed with the exception of the miscellaneous manufacturing enterprises.

In comparing the results by company size (Tables 10 and 11) it was observed that with the exception of Costa Rican firms with 400 to 600

Table 6. Utilization of Industrial Engineering Services in Costa Rican Industries. (All Respondents)

Category	Number	Per Cent
1. Companies with Industrial Engineering Staffs.	20	28.6
2. Companies Using only Consulting Services and/or Corporate Assistance	18	25.7
3. Companies with Industrial Engineering Staffs or Using Consulting Services and/or Corporate Assistance. (Combination of 1 and 2 above)	38	54.3
4. Companies that have never used Industrial Engineering Services	32	45.7

Note: Percentages were tabulated on the basis of the total number of responding companies.

Table 7. Utilization of Industrial Engineering Services in Georgia Industries. (All Respondents)

Category	Number	Per Cent
1. Companies with Industrial Engineering Staffs	54	69.2
2. Companies using only Consulting Services and/or Corporate Assistance	15	19.2
3. Companies with Industrial Engineering Staffs or using Consulting Services and/or Corporate Assistance. (Combination of 1 and 2 above)	69	88.4
4. Companies that have never used Industrial Engineering Services	9	11.6

Note: Percentages were tabulated on the basis of the total number of responding companies.

Table 8. Utilization of Industrial Engineering Services in Costa Rican Industries (By Industry Type)

	With I.E. Staff		I.E. Consulting Services		I.E. Staff or Consulting Service		Never use I.E. Services	
Industry Type	#	%	#	%	#	%	#	%
Textile	2	20.0	5	50.0	7	70.0	3	30.0
Food and Kindred Products	3	21.4	3	21.4	6	42.9	8	57.1
Plastic and Metal Industries	4	26.6	3	20.0	7	46.6	8	53.4
Chemical and Allied Products	5	29.4	5	29.4	10	58.8	7	41.2
Miscellaneous Manufacturing Enterprises	6	42.9	2	14.3	8	57.0	5	43.0
TOTAL	20		18		38		32	

Note: Percentages were tabulated on the basis of the number of responding companies within each industrial group.

Table 9. Utilization of Industrial Engineering Services in Georgia Industries (By Industry Type)

	With I.E. Staff		I.E. Consulting Services		I.E. Staff or Consulting Service		Never use I.E. Services	
Industry Type	#	%	#	%	#	%	#	%
Textile	20	95.2	0	0.0	20	95.2	1	4.8
Food and Kindred Products	10	62.5	3	18.7	13	81.2	3	18.8
Plastic and Metal Industries	10	66.6	3	20.0	13	86.6	2	13.4
Chemical and Allied Products	9	69.2	3	23.1	12	92.3	1	7.7
Miscellaneous Manufacturing Enterprises	5	38.4	6	46.2	11	84.6	2	15.4
TOTAL	54		15		69		9	

Note: Percentages were tabulated on the basis of the number of responding companies within each industrial group.

Table 10. Utilization of Industrial Engineering Services in Costa Rican Industries (By Company Size)

	With I.E. Staff		I.E. Consulting Services		I.E. Staff or Consulting Service		Never used I.E. Services	
Company Size	#	%	#	%	#	%	#	%
50 to 100 employees	4	25.0	2	12.5	6	37.5	10	62.5
100 to 200 employees	7	21.9	13	38.7	20	60.6	12	39.4
200 to 400 employees	5	41.3	3	27.3	8	66.6	4	33.3
400 to 600 employees	2	28.5	0	0.0	2	28.5	5	71.5
More than 600 employees	2	66.6	0	0.0	2	66.6	1	33.3
TOTAL	20		18		38		32	

Note: Percentages were tabulated on the basis of the number of responding companies within each size category.

Table 11. Utilization of Industrial Engineering Services in Georgia Industries (By Company Size)

	With I.E. Staff		I.E. Consulting Services		I.E. Staff or Consulting Service		Never used I.E. Services	
Company Size	#	%	#	%	#	%	#	%
50 to 100 employees	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
100 to 200 employees	10	47.6	7	33.3	17	80.9	4	19.1
200 to 400 employees	18	66.6	6	22.2	24	88.8	3	11.2
400 to 600 employees	14	82.3	1	5.9	15	88.3	2	11.6
More than 600 employees	12	92.3	1	7.7	13	100.0	0	0.0
TOTAL	54		15		69		9	

Note: Percentages were tabulated on the basis of the number of responding companies within each size category.

employees, in each larger size category (in both manufacturing systems), the relative use of Industrial Engineering services increased. This was also true with regard to the percentages of Industrial Engineering staffs in each size category for Georgia industries, however, this was not the case in Costa Rican industries. As far as consulting services were concerned, it was noticed from the responses of both surveys that these services were used mainly by the three smaller size categories, especially in Costa Rican industries.

The comparison of survey responses was valuable in showing that both manufacturing systems were consistent in certain aspects concerning the use of Industrial Engineering services. For example, the textile and chemical industries accounted for the largest use of these services in both locations. This could be partially attributed to two reasons: (a) the average employment size of the textile companies surveyed was larger than the average size of any other group investigated, and (b) the type of technology, quality standards and safety measurements characteristic of chemical processes usually call for specialized personnel.

Another consistency of responses was observed with regard to the distribution of services by company size, this probably has some validity and certainly was consistent with the expectations. However, it was significant that when these results were analyzed in more detail, the responses of the Costa Rican industries showed a high use of consulting services (specially in the three smaller size categories), while the Georgia responses emphasized the use of Industrial Engineering staffs in every size category.

The fact that manufacturing firms in Georgia (all respondents) were using Industrial Engineering services at a larger extent than Costa Rican industries could be attributed to the following reasons: (a) due to the stage of industrial development and to the availability of Industrial Engineers, Georgia manufacturers were more aware of the uses and needs for this professional resource, and (b) due to the small average size of Costa Rican industries, and to the limited knowledge by company owners and officials with regard to Industrial Engineering applications (as it will be discussed in latter sections of this chapter), the management staffs in Costa Rican companies felt that the use of Industrial Engineers was economically unprofitable or not necessary.

Objective No. 2

A second objective of the study was to identify those functional areas to which Industrial Engineers in Costa Rican industries were devoting their attention as compared to those Georgia industries with similar characteristics.

In order to collect the necessary data for this analysis, each company contacted in the surveys was asked to identify those activities in which they were using the expertise of Industrial Engineers. To guide the respondents in recognizing some of these activities, a list of what was judged to be the 20 functions most related to Industrial Engineering practice was provided on the questionnaires and space was made available for the respondents to write additional functions, if necessary. The responses were tabulated according to: (a) companies with Industrial Engineering staffs, and (b) all participating companies. (The last

category was considered to include those firms using consulting services and/or corporate assistance and to provide an analysis of the type of functions in which Industrial Engineering know-how is used among all respondents.) The results of the tabulated responses are presented in Tables 12 and 14, for the Costa Rican survey, and 13 and 15 for the Georgia survey.

Description of the Costa Rican Data

An analysis of the responses from those Costa Rican companies with Industrial Engineering staffs (Table 12) revealed that the expertise of these practitioners was being more frequently applied to the following functional areas: (in descending order of frequency)

- Cost Reduction
- Work Simplification
- Plant Facilities and Layout
- Storage Facilities Design
- Production Standards

Each of these five activities was reported by 70 per cent or more of the manufacturing firms within this group. Plant facilities and layout was not only listed more often by companies with Industrial Engineers but also more frequently by firms using only consulting services and/or corporate assistance. With respect to those functional areas which received the least amount of attention from Industrial Engineers in this group of companies, the following were reported by 35 per cent or less of the respondents: (in descending order of frequency)

- Labor Training
- Preventive Maintenance
- Inventory Control
- Quality Control
- Accident Prevention
- Scheduling and Dispatching
- Production Cost Analysis
- Materials Handling

An evaluation of the responses from all respondents (Table 14) shows that with the exception of plant facilities and layout, no other activity was performed by Industrial Engineers in 30 per cent or more of the surveyed companies. Furthermore, only cost reduction, expansion feasibility studies and work simplification accounted for 20 per cent or more of the total responses.

The overall distribution (order of frequency) of the functional areas reported by all respondents was for the most part consistent with the distribution provided by companies with Industrial Engineering staffs (Table 12). This was not surprising considering that those firms using only consulting services and/or corporate assistance usually apply these services to a very limited number of functional areas.

Comparison of Functional Areas to Which Industrial Engineers Devote their Attention in Costa Rican and Georgia Industries

In comparing the responses from those Costa Rican and Georgia industries with Industrial Engineering staffs (concerning the type of functional areas performed by Industrial Engineers, Tables 12 and 13) it was noticed that companies in this group category (in both manufacturing systems) were consistent in many of the activities in which they reported to be using the expertise of their Industrial Engineering personnel. An item by item comparison, showed that 7 of the 10 most frequently reported functions were common to both groups of companies. Even more, the responses of the surveys agreed in 2 of the 5 least reported areas. (It must be pointed out that the order of ranking of these activities was not the same in both surveys.) With regard to the percentage of companies utilizing Industrial Engineers in each of the reported areas,

Table 12. Type of Functional Areas to Which Industrial Engineers Devote their Attention in Costa Rican Industries (Companies with Industrial Engineering Staffs)

Type of Functional Area	Number	Per Cent
1. Cost Reduction Studies	19	95.0
2. Work Simplification	15	75.0
3. Plant facilities and Layout	14	70.0
4. Storage Facilities Design	14	70.0
5. Production Standards	14	70.0
6. Design of Production Processes	13	65.0
7. Time Studies and Standards	11	55.0
8. Labor Incentive Programs	10	50.0
9. Expansion Feasibility Studies	10	50.0
10. Production Planning and Forecasting	9	45.0
11. Labor Performance and Cost	9	45.0
12. Manpower Allocation	8	40.0
13. Labor Training	7	35.0
14. Preventive Maintenance	7	35.0
15. Inventory Control	7	35.0
16. Quality Control	7	35.0
17. Accident Prevention	6	30.0
18. Scheduling and Dispatching	6	30.0
19. Production Cost Analysis	5	25.0
20. Materials Handling	4	20.0

Note: Percentages were tabulated on the basis of the total number of responding companies within this group. (With Industrial Engineering Staffs)

Table 13. Type of Functional Areas to Which Industrial Engineers Devote their Attention in Georgia Industries (Companies with Industrial Engineering Staffs)

Type of Functional Area	Number	Per Cent
1. Work Simplification	45	83.3
2. Time Studies and Standards	44	81.4
3. Labor Performance and Cost	44	81.4
4. Plant Facilities and Layout	44	81.4
5. Cost Reduction Studies	44	81.4
6. Production Standards	42	77.7
7. Manpower Allocation	40	74.0
8. Production Cost Analysis	37	70.5
9. Design of Production Processes	31	57.4
10. Expansion Feasibility Studies	31	57.4
11. Labor Incentives	30	55.5
12. Production Planning and Forecasting	27	50.0
13. Materials Handling	22	40.7
14. Accident Prevention	18	33.3
15. Storage Facilities Design	18	33.3
16. Quality Control	17	31.5
17. Labor Training	16	30.0
18. Preventive Maintenance	14	26.0
19. Inventory Control	13	22.2
20. Scheduling and Dispatching	6	11.1

Note: Percentages were tabulated on the basis of the total number of responding companies within this group. (With Industrial Engineering Staffs)

Table 14. Type of Functional Areas to Which Industrial Engineers Devote their Attention in Costa Rican Industries (All Respondents)

Type of Functional Area	Number	Per Cent
1. Plant Facilities and Layout	22	31.5
2. Cost Reduction Studies	19	27.2
3. Expansion Feasibility Studies	19	27.2
4. Work Simplification	18	25.7
5. Production Standards	14	20.0
6. Storage Facilities Design	14	20.0
7. Design of Production Processes	13	18.6
8. Time Studies and Standards	11	15.7
9. Labor Incentive Programs	10	14.3
10. Production Planning and Forecasting	9	12.9
11. Labor Performance and Cost	9	12.9
12. Manpower Allocation	8	11.5
13. Labor Training	7	10.0
14. Preventive Maintenance	7	10.0
15. Inventory Control	7	10.0
16. Quality Control	7	10.0
17. Accident Prevention	6	8.6
18. Scheduling and Dispatching	6	8.6
19. Production Cost Analysis	5	7.2
20. Materials Handling	4	5.7

Note: Percentages were tabulated on the basis of the total number of responding companies.

Table 15. Type of Functional Areas to Which Industrial Engineers Devote their Attention in Georgia Industries (All Respondents)

Type of Functional Area	Number	Per Cent
1. Plant Facilities and Layout	48	61.4
2. Work Simplification	47	60.0
3. Cost Reduction Studies	46	58.8
4. Time Studies and Standards	46	58.8
5. Labor Performance and Cost	44	56.3
6. Production Standards	43	55.0
7. Manpower Allocation	40	51.2
8. Production Cost Analysis	37	47.4
9. Expansion Feasibility Studies	37	47.4
10. Design of Production Processes	32	41.9
11. Labor Incentives	31	39.7
12. Production Planning and Forecasting	27	34.6
13. Materials Handling	24	30.7
14. Quality Control	19	24.3
15. Accident Prevention	18	23.0
16. Storage Facilities Design	18	23.0
17. Labor Training	16	20.5
18. Inventory Control	14	18.0
19. Preventive Maintenance	14	18.0
20. Scheduling and Dispatching	6	7.7

Note: Percentages were tabulated on the basis of the total number of responding companies.

Georgia firms showed higher percentages in all areas but the following:

- Cost Reduction
- Storage Facilities Design
- Design of Production Processes
- Labor Training
- Preventive Maintenance
- Quality Control
- Inventory Control
- Scheduling and Dispatching

This may be attributed to the fact that in developed industrial systems (Georgia) these functions are usually performed by specialized personnel, while in developing manufacturing systems (Costa Rica) this type of personnel is not available, thus, in most cases the Industrial Engineer is used to cope with problems in these areas.

In comparing the responses from all participating firms (Tables 14 and 15) it was noticed again that 7 of the 10 most frequently reported areas were common to both groups of industries. However, the order of ranking of these functions was different from that of companies with Industrial Engineers (Table 12). Plant facilities and layout was the most frequent area reported by all respondents in Georgia and Costa Rica. This seems to indicate that those firms using consulting services and/or corporate assistance were utilizing these services mainly to design or improve their manufacturing facilities and plant layouts. The answers from all respondents also showed that with the exception of scheduling and dispatching, the percentage of companies using Industrial Engineers in all other areas listed was higher in Georgia than in Costa Rica.

The comparison of Georgia and Costa Rican responses seems to indicate that: (a) for the most part, companies in both manufacturing systems were consistent in their use of Industrial Engineers in those areas most

frequently reported, and (b) the expertise of Industrial Engineers is more widely utilized (by a larger number of firms) in Georgia than in Costa Rica.

Objective No. 3

The third objective of the study was to determine which, if any, organizational functions that may call for Industrial Engineering expertise were considered by Costa Rican managers as significant problem areas in their firms. To assist the respondents in identifying some of the problem areas, a list of what was judged to be the 20 activities most related to Industrial Engineering was provided on the questionnaire and space was made available for the respondents to write additional problem areas, if necessary.

The responses were classified in three categories: (a) firms with Industrial Engineering staffs, (b) firms without Industrial Engineering staffs, and (c) all participating firms. This classification of responses was used to determine if any relationship existed between the number of problems reported by each group category and their respective use of Industrial Engineering services. The tabulated answers are presented in Tables 16, 17 and 18. A more detailed analysis of individual problems by industry type and company size is shown in Table 11-A of Appendix A of this report.

Description of the Data

According to a majority of the companies that responded to the questionnaire (Table 16), the most common problem encountered in the Costa Rican manufacturing sector was related to manpower activities.

Of the 70 respondents, a total of 41 or a little more than 58 per cent reported problems in the area of labor performance and cost. In addition, 28 per cent of the firms acknowledged difficulties with the administration of incentive programs. Other problems cited by more than one-third of the participants were in the areas of production cost analysis, cost reduction, quality control and inventory control. Fewer problems were recognized in activities related to facilities design and layout, production standards and accident prevention. None of these three areas was reported by more than 5 per cent of the respondents.

Six areas of the 20 listed on the questionnaire, were not reported by any of the responding firms. This may be attributed to two possible reasons: (a) the respondents did not have a complete understanding of what was considered to be a problem in each of these areas, or (b) none of the participating firms had difficulties with these areas, which is very improbable.

An evaluation of the individual problems reported by those companies with Industrial Engineering staffs (Table 17), showed that difficulties most frequently cited by this group of firms were related to cost reduction, inventory control, quality control and labor performance and cost. However, none of these four areas accounted for more than 40 per cent of the responses, and no other type of problem was reported by 20 per cent or more of the firms in this group.

An analysis of the responses from firms without Industrial Engineering staffs, showed that 10 of the 14 problem areas reported were recognized by 20 per cent or more of the firms in this group. Furthermore, the following areas were listed by one-third of more of the respondents:

Table 16. Types of Problem Areas Encountered in Costa Rican Industries (All Respondents)

Type of Problem Area	Number	Per Cent
1. Labor Performance and Cost	41	58.7
2. Production Cost Analysis	29	41.5
3. Cost Reduction	27	38.7
4. Quality Control	21	33.0
5. Inventory Control	21	33.0
6. Production Planning and Forecasting	20	28.6
7. Feasibility Studies	20	28.6
8. Labor Incentive Programs	19	27.1
9. Preventive Maintenance	19	27.1
10. Design of Production Processes	15	21.5
11. Work Simplification	10	14.3
12. Accident Prevention	3	4.3
13. Production Standards	3	4.3
14. Facilities Design and Layout	1	1.4

Note: Percentages were tabulated on the basis of the total number of respondents.

Table 17. Types of Problem Areas Encountered in Costa Rican Industries (Companies with I.E. Staffs)

Type of Problem Area	Number	Per Cent
1. Cost Reduction	8	40.0
2. Inventory Control	8	40.0
3. Quality Control	7	35.0
4. Labor Performance and Cost	7	35.0
5. Production Cost Analysis	4	20.0
6. Design of Production Processes	4	20.0
7. Labor Incentive Programs	4	20.0
8. Production Planning and Forecasting	3	15.0
9. Preventive Maintenance	2	10.0
10. Feasibility Studies	2	10.0
11. Work Simplification	2	10.0
12. Accident Prevention	0	0.0
13. Production Standards	0	0.0
14. Facilities Design and Layout	0	0.0

Note: Percentages were tabulated on the basis of the total number of responding companies within this group. (Firms with Industrial Engineering Staffs.)

Table 18. Types of Problem Areas Encountered in Costa Rican Industries (Companies without I.E. Staffs)

Type of Problem Area	Number	Per Cent
1. Labor Performance and Cost	34	68.0
2. Production Cost Analysis	25	50.0
3. Cost Reduction	19	38.0
4. Feasibility Studies	18	36.0
5. Production Planning and Forecasting	17	34.0
6. Preventive Maintenance	17	34.0
7. Labor Incentive Programs	15	30.0
8. Quality Control	14	28.0
9. Inventory Control	13	26.0
10. Design of Production Processes	11	22.0
11. Work simplification	8	16.0
12. Accident Prevention	3	6.0
13. Production Standards	3	6.0
14. Facilities Design and Layout	1	2.0

Note: Percentages were tabulated on the basis of the total number of responding companies within this group. (Firms without Industrial Engineering Staffs.)

(in descending order of frequency)

- Labor Performance and Cost
- Production Cost Analysis
- Cost Reduction
- Feasibility Studies
- Production Planning and Forecasting
- Preventive Maintenance

In comparing the results from companies with and without Industrial Engineering staffs, it was noticed that firms without Industrial Engineering personnel not only were experiencing more types of problems, but also a larger percentage of difficulties in all areas reported with the exception of quality control, inventory control and cost reduction.

Objective No. 4

A fourth objective of the study was to identify, in those companies that had never used Industrial Engineering services, what were the most important managerial reasons for not utilizing this professional resource.

In order to make it easier for the respondents to state their reasons without the need for long descriptions, a list of what were considered to be the 4 most logical reasons for management not to use these services was provided on the questionnaire and space was made available for writing additional information if necessary. The responses were tabulated on the basis of the total number of firms that indicated that they had never used Industrial Engineers. The results are presented in Table 19.

Description of the Data

An evaluation of the responses to this inquiry revealed that two out of every three costa Rican firms not using Industrial Engineering

services, attributed this to the lack of justification for this type of service within the company. Management indifference was listed as a reason by 16 per cent of the respondents, whereas the cost of the service, the difficulty of finding Industrial Engineers in the country and other miscellaneous reasons accounted in each case for only 6 per cent of the answers.

Further interpretation concerning this lack of justification and management indifference for Industrial Engineering assistance, is provided throughout the discussion of case histories in the next section of this chapter.

Case History Investigations

One of the primary purposes of the detailed investigation of a number of manufacturing firms in Costa Rica was to develop information which could be helpful in providing further interpretation of some of the survey findings and in confirming some of the survey results. Although the data collected through the questionnaire survey was, in most instances, clear-cut and decisive, it was felt that additional information was necessary to answer the following questions: Do the nature and the causes of the problems reported by Costa Rican industries call for Industrial Engineering solutions as was assumed in designing the list of possible problem areas for the questionnaire? Can Industrial Engineering expertise be of assistance to developing industries or is there no justification for this type of service in these industries as expressed by some of the respondents? Why did a considerable number of companies report no need for Industrial Engineers, was this because these

Table 19. Classification of Reported Managerial Reasons for not Using Industrial Engineering Services

Managerial Reasons	Number	Per Cent
1. Have not justified the function of Industrial Engineers in our company	21	65.5
2. Management Indifference for this type of Services	5	15.6
3. Services are too costly	2	6.3
4. Hard to find Industrial Engineers in Costa Rica	2	6.3
5. Other Reasons	2	6.3
TOTAL	32	100.0

Note: Percentages were tabulated on the basis of the total number of responding companies which indicated that they had never used Industrial Engineering Services.

firms did not have any problems that call for the expertise of these practitioners or are there other interpretations of these responses?

In order to provide answers to each of these questions, fourteen companies were chosen (after questionnaire responses had been received) for case history investigations. Five of these companies (which provided the necessary information to answer the stated questions) were selected for further discussion in this report. A summary of these five investigations is presented. A more detailed discussion of each case history investigation appears in Appendix C of this report.

While some of the interpretations provided in this section grew out of a general understanding which developed over the entire case history phase, others are related to the specific experiences of the five individual firms described in this chapter. In the latter case, the companies are identified by number (not by name) to maintain the anonymity requested by the participants.

Description of Case History Results

Nature and Causes of Problems Reported by Costa Rican Industries.

The case history investigations provided an opportunity to analyze in more detail the nature and causes of some of the most common problems listed by the survey respondents.

An evaluation of the operational and organizational procedures of case history companies No. 1 and No. 2, left little doubt that the problems were real and in critical need of solution. The experiences of company No. 1 illustrated the type of manpower difficulties commonly found among the firms investigated. (Also the most frequent problem area cited by the survey respondents.) Some of the personnel problems

Table 20. Summary of Case History Investigations

Case History Number	Characteristics of Case History Firm	Reasons for Case History	Findings of Case History	Conclusions of Case History
# 1	Food Industry (Candy and Cookies) 250 employees Family-held	To investigate the nature and causes of manpower problems.	The manager described the company's manpower problem as including: poor productivity, high absenteeism and turnover, low employee morale, low employee skills and unusual training needs. The investigation showed that the problems had originated from lack of training methods, poor management-labor relations, inefficient incentive programs and lack of personnel capable to cope with the problems.	The nature and causes of manpower problems in this firm call for Industrial Engineering applications.
# 2	Zipper Industry 250 employees Manager part-owner	To investigate the nature and causes of problems other than manpower.	Some of the problems experienced by this firm were in the areas of quality control, inventory control, materials handling, plant layout and production planning. The investigation showed that, for the most part, the problems had originated from lack of Industrial Engineering methods or from the inefficient application of these methods.	The nature and causes of the problems of this company call for Industrial Engineering expertise.
# 3	Chemical Industry (beauty items) 50 employees Division of Corporation Young company	To investigate why the manager of this firm reported that Industrial Engineering services were not justified in the company.	The manager felt that the size of the company and the magnitude of the existing problems made it economically unprofitable at the present time to hire Industrial Engineers or to pay for consulting services. However, he recognized that the use of this service could be very beneficial for the company.	This company did not justify the use of Industrial Engineers not because these professionals were not needed but because the firm could not afford to pay for the service.
# 4	Plastic Products Industry 200 employees Family-held Traditional production methods.	To investigate why the manager of this firm reported that Industrial Engineering services were not justified in the company	This company was experiencing many of the common problems that call for Industrial Engineering expertise. The manager was aware of these problems, however, he could not see how Industrial Engineers could help the company in coping with these problems. For that reason he felt that the use of Industrial Engineers was not justified in the company.	This company did not justify the use of Industrial Engineers not because the services of these professionals were not needed, but because lack of management knowledge concerning the uses and benefits of Industrial Engineering applications.
# 5	Rubber Industry (Tire Manufacturer) 577 employees Division of a Corporation. Has I.E. staff.	To investigate the use of Industrial Engineering services in a developing industry.	This company had used Industrial Engineers in coping with the type of problems commonly founded in Costa Rican industries. By using these professionals, the firm had minimized and, in some instances, prevented most of these problems. The type of applications used in this company were based on basic Industrial Engineering concepts, rather than sophisticated quantitative techniques. Although the company was not problem-proof, the use of Industrial Engineers had helped to achieve high operational efficiency.	This company showed that Industrial Engineering methods can be used to cope with those common problems founded in Costa Rican industries. Furthermore, it showed that for the most part, these problems call for basic Industrial Engineering solutions, rather than sophisticated quantitative techniques.

experienced by this company, as described by the manager-owner, were: low worker productivity, high absenteeism and turnover, low employee morale, low employee skills and unusual training needs. Throughout the investigation of this firm, it became evident that some of the causes that had originated these problems were: lack of formal training methods, no labor management relations programs, inefficient administration of incentive programs, and lack of personnel capable of coping with manpower difficulties.

The experiences of company # 2 provided similar conclusions with regard to the nature and causes of problems other than manpower. This company was founded to be experiencing difficulties in areas related to: quality control, inventory control, plant layout, materials handling production cost analysis and production planning and forecasting. In each of these areas it was observed that for the most part, the problems had originated from the lack of existing methods to cope with the problems or from the ineffective applications of these methods.

In summary, the case history investigations and more specifically companies # 1 and # 2, provided the opportunity to draw the following conclusions: (1) the problems were real and in critical need of solution, and (2) as it was assumed in designing the questionnaire problem list, for the most part, the existing problems in Costa Rican industries call for Industrial Engineering expertise.

Interpretation on the Reported Lack of Justification and Management Indifference for Industrial Engineering Services in Costa Rican Industries. One salient question emerged from the analysis of survey results. Why did almost half of the participating companies report no need for Indus-

trial Engineering services, while a majority of the respondents were able to recognize a considerable number of problem areas in their firms which call for Industrial Engineering expertise?

An interpretation of this apparent inconsistency of response was provided by the case history investigations. By the reactions of case history firms # 3 and # 4 to the questions of problems and needs, it became evident that some Costa Rican manufacturers do not use Industrial Engineers, not because the services of these professionals are not needed in these companies, but more likely for the following reasons: (1) in small firms, as it was the case of company # 3, the management felt that the size of the organization and the magnitude of the existing problems made it economically unprofitable to hire Industrial Engineers or to pay for outside consulting assistance. Nevertheless, the manager of this company recognized that the use of Industrial Engineering services could be very beneficial for the firm but through that it would be unpractical to justify these services at this stage of industrial development, and (2) another group of firms, as was the case of company # 4, reported no need for Industrial Engineering assistance not because their problems did not call for the use of this professional resource, but due to the lack of management knowledge concerning the uses and needs for Industrial Engineering. In other words, even though the owners and management staffs were aware of the existing problems, they were not aware of how Industrial Engineering methods could be used to cope with these problems.

In summary, the results of the case histories (particularly those of companies # 3 and # 4) were helpful in showing that the survey

responses concerning the lack of justification and management indifference for Industrial Engineering services did not imply that these services were not needed in Costa Rican firms, but more likely that these companies had failed to utilize this professional resource for economical reasons or due to lack of awareness concerning the use of this professional resource.

Use of Industrial Engineering Services in a Developing Industry. Case history firms # 1 and # 2 were used to illustrate that for the most part, the type of problems reported by Costa Rican industries called for Industrial Engineering expertise. The results of case history investigation # 5 not only helped to confirm this, but also to prove that Industrial Engineering methods could be used to solve and, in some instances, prevent many of the problems commonly found in developing industries. Furthermore, this investigation was useful in showing that the types of problems experienced by these companies could be handled through basic Industrial Engineering techniques rather than sophisticated quantitative solutions.

In summary, this case history investigation was valuable to the extent that verified that Industrial Engineering services could be very beneficial to developing industries.

Summary and Discussion of Results

The discussion of results which follows is based upon the survey data presented in previous sections. Confirmation, interpretation and expansion of these results were made possible by the detailed investigation and analysis of operations and experiences of a number of Costa

Rican manufacturing firms. Although some of the results discussed in this section were stated or implied throughout the presentation and description of the data, they are analyzed here in more detail for convenience in considering the answers to three of the four questions that motivated this study: 1) What operational problems that may call for Industrial Engineering expertise are being experienced by Costa Rican industries? 2) What specific needs for Industrial Engineering applications arise from these problems? 4) How are these needs presently being met?

An answer to the fourth question -- What can be done to help meet these needs more effectively? -- will be the topic of discussion of Chapter V.

A note of explanation should precede the discussion of results. Although some comparison of variables is made in discussing the data, due to the use of survey methodology, rather than controlled experimentation, no attempt is made here to prove cause and effect for any relationship discussed.

Problems and Needs for Industrial Engineering Services in Costa Rican Industries

An evaluation of the problem areas reported by Costa Rican manufacturing firms (Table 16) revealed that the three most common operational problems experienced by these companies were related to the areas of: (in descending order of frequency)

- Manpower Activities
- Cost Reduction
- Production Cost Analysis

The concern showed in these areas is of significance when considering

that Costa Rica is a labor intensive economy with limited amount of capital resources. This means that the success of the industrialization process lies heavily on the efficient use of manpower resources and on the minimization of capital expenses.

Other problem areas cited by more than one-third of the respondents were quality control and inventory control. Here again the results are significant because they reflect the concern that is developing over the recent established national quality standards and on the need for more effective inventory policies required to cope with the increasing demand of domestic and foreign markets. Furthermore, it indicates that Costa Rican firms are becoming more concerned with regard to cash flow problems.

The fact that quality control and inventory control were listed as problem areas by a slightly higher percentage of firms with Industrial Engineering staffs than companies without Industrial Engineering personnel, probably means that the presence of these practitioners had helped management to become more acutely aware of the importance of these operational areas and of the need for effective methods of coping with them.

Six problem areas of the original list of 20 provided on the questionnaire were not reported by any of the participating companies. This could be attributed to two possible reasons: (1) the respondents failed to recognize difficulties in each of these areas, or (2) none of the manufacturers was experiencing problems in these areas, which is very improbable.

Without deemphasizing the critical nature of the reported problems, the case history investigations showed that many had originated from the failure of company officials to observe basic principles of Industrial Engineering and management sciences. Furthermore, the analysis of responses from firms with Industrial Engineering staffs (concerning the use of Industrial Engineering expertise and the type of operational problems experienced -- Tables 12 and 17) revealed that for the most part, those areas to which Industrial Engineers were devoting their attention were the same ones which presented the less amount of difficulty to these companies.

In view of the type and number of problems reported by Costa Rican industries and on the fact that the use of Industrial Engineering expertise showed to be an effective mean to cope with these problems, it becomes evident that a wider practice of Industrial Engineering methods is needed within the country's manufacturing sector.

The specific areas in which Industrial Engineering could be most helpful to Costa Rican manufacturers are: (in descending order of need)

- Manpower Utilization
- Production Cost Analysis
- Cost Reduction
- Quality Control
- Inventory Control

Furthermore, case history # 5 showed that these types of problems were in need for basic Industrial Engineering techniques rather than sophisticated quantitative solutions.

Actual Use of Industrial Engineering Services in Costa Rican Industries

The results of the survey responses showed that while a majority of the participating companies were able to recognize a considerable

number of problem areas, almost half of the respondents indicated that they had never used Industrial Engineering services. Further interpretation of these results was provided by the study of case history firms. These investigations revealed that the non-use of this professional resource was not due to the lack of need for these services within these firms but to the fact that in many cases the companies were too small to make it economically profitable to pay for these specialized services, and in other instances the managerial knowledge concerning the uses of Industrial Engineering methods was too limited to recognize the benefits to be obtained from the application of these methods.

It was also observed from the responses from those firms with Industrial Engineering staffs that these companies were not utilizing the expertise of these practitioners as much as those Georgia industries with similar characteristics. This perhaps was due to the fact that they had failed to recognize that some of their problems could be handled by Industrial Engineering methods. A typical example was manpower problems.

In summary, the results of the research phase (concerning the actual use of Industrial Engineering services in Costa Rican industries) showed that: (a) Industrial Engineering expertise was not being utilized by Costa Rican manufacturers as much as the existing industrial needs seem to require (or as much as their Georgia counterparts were doing it), and (b) those firms with Industrial Engineering personnel were not utilizing to their full extent the skills of these practitioners (as Georgia industries seem to be doing).

In view of the previous considerations, it becomes necessary to consider the answer to the last question that motivated this study -- What can be done to meet the needs for Industrial Engineering expertise more effectively in Costa Rican industries?.

CHAPTER V

RECOMMENDED APPROACHES TO IMPROVE INDUSTRIAL ENGINEERING PRACTICE IN COSTA RICAN INDUSTRIES

The recommendations which follow in this chapter are directed to answer the last and most significant of the four questions which motivated this research study -- What can be done to meet the needs for Industrial Engineering assistance more effectively in Costa Rican industries?. (The answer to this question was also the fifth objective of the study.)

The recommendations provided in this chapter are not arbitrary but are based on a careful consideration of the practicality and feasibility of recommended approaches after analyzing and reviewing the survey results and after conducting probing discussions with Costa Rican managers (case histories) regarding the appropriate role of Industrial Engineers in resolving company problems and needs.

Recommended Approaches

(a) Industrial Engineering Assistance to Medium and Small Scale Industries

CONSIDERING:

(1) That approximately 85 per cent of the manufacturing establishments in Costa Rica fall in the category of medium and small scale industries (less than 150 employees) (35).

(2) That the survey conducted in this study showed that firms in

this category were not using Industrial Engineering assistance to the extent that the industrial needs seem to require.

(3) That the case history investigations indicated that some of these firms do not use Industrial Engineering services because it is economically unprofitable or due to limited management knowledge concerning the uses of this professional resource.

(4) That 83 per cent of those companies that participated in the survey study (Table 8-A, Appendix A), reported that they would be interested in using Industrial Engineering services if a non-profit assistance program could be established.

IT IS RECOMMENDED:

(1) That an Industrial Engineering assistance office be created in Costa Rica for the purpose of promoting the use of Industrial Engineering services among medium and small scale industries and to provide advisory services and field assistance to these firms. (Large companies are excluded from this recommendation because usually they have specialized staffs or have the means to obtain further assistance from private sources or from their foreign contacts.)

(2) That this agency be administratively organized on an autonomous basis (non-governmental). This was the opinion of 72 per cent of the survey respondents (Table 8-A, Appendix A). Furthermore, this type of organization provides the following advantages: (a) it makes it free of bureaucratic complex practices which usually hinder prompt responses, which are essential for effective service, (b) it makes it dedicated to serve any industry that needs its services, rather than public or private

companies, (c) the staffs must be competent and dedicated -- a condition that is difficult to attain with the salary schedules of government agencies, and (d) it provides freedom to maintain strictly confidential any information passed between institution and client.

(3) That this office be a non-profit organization financed from the following sources of capital: (1) during the first year, the necessary capital to operate and organize this agency should come from available domestic and international funds (domestic -- Industrial Development Fund of the Department of Industry and Industrial Assistance Fund of the Costa Rican Chamber of Industry (3,35); international -- The United Nations Special Fund which has financed similar programs (36)), and (2) after the first year of operation, the office should be financed by the revenues from services rendered to the industry (as it was the opinion of 83 per cent of the survey respondents -- Table 8-A, Appendix A).

(4) That this office be closely related to an information center (university or school of technology) so that it will have access to existing documentation (library services) in the field of Industrial Engineering and related areas.

(5) That this office should not be designed to replace any of the existing industrial development organizations (Industrial Engineering Office of the Department of Industry and Industrial Development Agency of Costa Rica) but to work in conjunction with them for the purpose of providing more efficient services to medium and small scale industries. (The two institutions cited above were established to promote industrial development and not to give direct field assistance to manufacturing

firms -- this was confirmed by the survey response in which only one of the 70 participating companies acknowledged to had received assistance from these organizations, Table 5-A, Appendix A.)

(6) That the primary functions of the proposed assistance agency be to: (a) assist and advise new industries by means of feasibility studies, selection of plant sites, requirements for equipment and personnel, manufacturing processes or any other Industrial Engineering activity, (b) assist and advise established medium and small scale industries whose performance needs to be improved by providing advisory services or field assistance (in short-term basis) on any management and Industrial Engineering area as it may be required, (c) conduct short training courses for the purpose of preparing and informing owners and company officials on the uses and needs for Industrial Engineering assistance, (d) to promulgate among medium and small scale industries, the requirements established by the National Quality Standards, and assist them in developing quality control programs, and (e) work in conjunction with the existing industrial development agencies in drawing up programs and adopting measures for the promotion of Industrial Engineering and managerial assistance to medium and small scale industries.

In summary, this recommended program will help to fulfill the needs for Industrial Engineering expertise among medium and small scale companies in Costa Rica. Similar assistance programs have been established in other developing countries for the same purposes. In each case, the results have been highly beneficial not only for the individual companies, but also for the industrial development of the countries. Some examples

of this type of program in other nations are: The Small and Medium Enterprise Agency -- Japan (37), Small Industry Training Institute -- India (38), and The Small Industries Services Institute -- Thailand (39).

(b) Educational Programs for Non-Industrial Engineering Personnel

CONSIDERING:

(1) That during the past ten years 612 new manufacturing companies were established in Costa Rica and that the projections of the Department of Industry indicate that a similar number of companies will be established in the next five years (1975-1980) (35).

(2) That Costa Rica actually has only 58 university graduate Industrial Engineers and that the University of Costa Rica projects to graduate during the next five years (1975-1980) only 180 Industrial Engineers. (Information provided for this study by the Industrial Engineering Department of the University of Costa Rica -- Exhibit 1, Appendix D.)

(3) That 87 per cent of the companies that responded to the survey indicated that they had formal plans for expansion during the next five years (Table 13-A, Appendix A).

(4) That based on the previous considerations (1, 2 and 3), it seems that the number of available Industrial Engineers in the next five years (1975-1980) won't be sufficient to meet the needs of the country's industry.

(5) That the management of some of the companies investigated felt that it could be more beneficial to the firm to train their technical personnel in areas related to Industrial Engineering than to use

consulting services from personnel not acquainted with the organization.

IT IS RECOMMENDED:

(1) That an Industrial Engineering educational program be established for the purpose of instructing non-Industrial Engineering personnel in areas related to this profession.

(2) That this program be coordinated by the Industrial Engineering Department of the University of Costa Rica and that the courses be taught by the faculty of this department, with outside assistance, as needed.

(3) That the courses offered be related to those areas of greatest need among the industry.

(4) That this program be financed by fees paid by participating companies.

(5) That this program be evaluated and updated periodically by means of feedback obtained from the companies involved.

In summary, the recommended program is intended to provide an opportunity for manufacturing firms to meet their Industrial Engineering needs through the use of their own personnel. Furthermore, it may allow a wider practice of Industrial Engineering methods in industry where it would not be feasible otherwise, considering the limited availability of Industrial Engineering graduates in the country.

(c) Adaptation of Industrial Engineering Education to the Needs of the Country's Industry

CONSIDERING:

(1) That many Costa Rican managers felt that the present Industrial Engineering graduates were overeducated for the needs of the

country's industry and that they were not provided with practical experience as part of their education.

(2) That the results of the investigations conducted in this study showed that the areas of greatest need among Costa Rican industries call for the application of basic Industrial Engineering principles, rather than sophisticated quantitative techniques.

(3) That the country does not have the necessary computer facilities or information sources for the effective practice of quantitative methods.

(4) That the Industrial Engineering curriculum of the University of Costa Rica (Exhibit # 2, Appendix D), was designed to meet the requirements of those programs established in developed countries, rather than to meet the needs of the developing industries.

IT IS RECOMMENDED:

(1) That the Industrial Engineering Department of the University of Costa Rica reevaluate its present educational program so as to put emphasis in those areas of greatest need for assistance to industry. (These areas are shown in Table 16.)

(2) That this educational program be reviewed and updated on a periodic basis in order to adapt it to the level of the country's technological development.

(3) That senior Industrial Engineering students be required to do practical field work in a manufacturing firm or in an industrial development agency as part of their educational program.

(4) That, when possible, Industrial Engineering students be required to do research in those operational areas that are most critical

among Costa Rican industries.

In summary, this recommendation is intended to provide Industrial Engineering students with a better background for their task of coping more effectively with the problems and needs of the country's industry.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The purpose of this thesis has been to study the uses and needs for Industrial Engineering in Costa Rica. This research was also intended to provide a comparison of the utilization of Industrial Engineering services between a developing industrial system (Costa Rica) and a more developed manufacturing system with large resources in the field of Industrial Engineering (State of Georgia, U.S.A.).

The specific objectives of the study were (1) to determine to what extent Industrial Engineering services were being used in Costa Rican industries as compared to industries with similar characteristics in the State of Georgia, (2) to identify the functional areas to which Industrial Engineers devote their attention in Costa Rican industries as compared to those Georgia industries with similar characteristics, (3) to determine which organizational functions that call for Industrial Engineering expertise were being perceived by Costa Rican managers as significant problem areas in their organizations, (4) to identify, in those Costa Rican companies that have never used Industrial Engineering services, what were the most important managerial reasons for not utilizing this professional resource, and (5) to propose specific ways to improve Industrial Engineering practice in Costa Rican industries in view of the existing industrial needs.

The paragraphs below summarize the research methodology used. The

conclusions drawn from the research results are described. Finally, areas for further study are identified.

Summary of Research

The research phase of this study consisted of two questionnaire surveys conducted among manufacturing firms in Costa Rica and the State of Georgia. Questionnaire forms were mailed to 100 companies in Costa Rica and 100 in Georgia. The participating firms were chosen from the following industrial groups: (a) Textiles, (b) Food and Kindred Products, (c) Plastic and Metal Industries, (d) Chemical and Allied Products, and (e) Miscellaneous Manufacturing Enterprises. The responding companies ranged in size from 50 to more than 600 employees. Of the total number of questionnaires mailed, 70 responses were received from Costa Rican industries (70%) and 78 from Georgia manufacturers (78%). An analysis of the validity, reliability and sampling biases of the survey data was conducted throughout the study and although the validity of certain items was questionable, the overall results were considered valid enough to draw meaningful conclusions. Confirmation, interpretation and expansion of the Costa Rican survey results were made possible by the detailed investigation and analysis of operations and experiences of fourteen manufacturing firms which were representative of the responding group (Case History Investigations).

The analysis of questionnaire data and the results of the case history investigations are presented in Chapter IV of this report.

Conclusions

The conclusions presented here are based upon the results of the

research study and other literature surveyed in this report. Some of the conclusions are subject to the validity, reliability and sampling biases of the data collected and they must be interpreted with these considerations in mind. The following are the major conclusions drawn from the study:

1. Based on the type and number of operational problems reported by the Costa Rican survey respondents, it is concluded, that the country's industry has a need for Industrial Engineering services.

2. Based on the analysis of responses concerning uses and needs for Industrial Engineering in Costa Rican firms, it is concluded, that the country's manufacturing sector is not utilizing Industrial Engineering services to the extent that the industrial needs seem to require.

3. From the comparison of Georgia and Costa Rican survey results, it is concluded, that Georgia industries are not only using Industrial Engineering services to a larger extent than those Costa Rican industries with similar characteristics, but also they are applying these services more effectively.

4. It is concluded, that for the most part, the type of problems reported by Costa Rican industries originate from management's failure to observe certain principles of Industrial Engineering and management sciences. Furthermore, most of these problems could be handled through basic Industrial Engineering applications rather than sophisticated quantitative techniques.

5. It is concluded, that many Costa Rican firms do not use Industrial Engineering assistance, not because this type of assistance is not needed in these companies, but because (1) small firms feel that it

is economically unprofitable to pay for specialized services (85% of the country's manufacturers may fall in this category), and (2) management staffs are not totally aware of the uses and needs for Industrial Engineering applications.

6. It is concluded, that the operational areas in which Industrial Engineering expertise could be more helpful to the country's industry are: manpower utilization, cost reduction, production cost analysis, quality control and inventory control.

7. Based on the responses from those Costa Rican companies with Industrial Engineering staffs, it is concluded, that the use of Industrial Engineering expertise could help to improve the operational efficiency of developing industries. (This group of companies were found to be experiencing a lower percentage and number of problems than those firms without Industrial Engineering personnel, furthermore, the organizational functions that were perceived less frequently by them as problem areas were the same ones to which their Industrial Engineers were devoting most of their attention.)

8. From the evaluation of (1) the Industrial Engineering curriculum of the University of Costa Rica, and (2) the needs of the country's industry, it is concluded, that the present educational program for Industrial Engineers is not adequate to meet satisfactorily the needs of the manufacturing sector.

9. Based on the country's projected industrial development for the next five year period (1975-1980), it is concluded, that it will be very difficult to meet the needs for Industrial Engineering services in the manufacturing sector with the projected number of university graduate

Industrial Engineers.

In summary, the study indicates that even though there is a need for Industrial Engineering service in Costa Rican industries, this service is not being utilized by the manufacturing sector to the extent that the industrial needs seem to require, because small companies feel they are unable to pay for this service and because management staffs are not aware of the uses and needs for this professional resource. The study also indicated that Georgia industries were utilizing Industrial Engineering services more frequently and more effectively than those Costa Rican industries with similar characteristics. From the research results, it was concluded, that better methods should be established to improve Industrial Engineering practice in Costa Rican industries. In Chapter V of this report, three specific methods are recommended: 1) the establishment of a non-profit Industrial Engineering Office to assist medium and small scale industries, 2) the creation of a Industrial Engineering educational program for non-Industrial Engineering personnel, and 3) the adaptation of the Industrial Engineering Cirriculum of the University of Costa Rica to the present needs of the industry.

Recommendations for Future Research

Two types of recommendations for future research are offered in this section. The first set is directed to those persons conducted similar studies; the second set consists of recommendations for further research on the approaches suggested in this report (Chapter V) for the improvement of Industrial Engineering practice in Costa Rican industries.

Recommendations for Similar Studies

The following recommendations for similar studies are based on the experiences obtained from the preparation of this report.

1. Before a research of this nature is initiated (not necessarily concerning Industrial Engineering) it is essential to formulate a statement of the problem or situation that is to be investigated or surveyed. This will help to organize and clarify the objectives of the study and to determine if the potential results are already known.

2. If survey methodology is to be used, as it was in this study, careful consideration must be given to the design of questionnaire forms to insure that (1) the items included are directly related to the information desired, (2) the questions asked are clear and easy to understand, (3) the data collected will be valid and reliable, and (4) the effect of sampling biases will be minimized.

3. To insure that the information collected will be useful for the objectives of the research, a pre-test survey should be conducted. This will help to determine how the data will be used, what additional information could be necessary, and what type of information is redundant. In general, the survey pre-test will allow the necessary revisions to the questionnaire form before the final survey is conducted.

4. After the data has been collected, test for validity and reliability of results must be conducted if possible to insure that the information is fitted for the purposes of the study.

5. Finally, if the research is concerned with the study of the uses and needs of a professional discipline by an economic sector, as was the case of this report, the answers to the following questions must

be considered: 1) What operational problems that call for the expertise of that professional discipline are most critical in that economic sector? 2) What specific needs for that professional discipline arise from those problems? 3) How are those needs presently being met? and 4) What can be done to meet those needs more effectively?

Recommendations for Further Research on Proposed Ways to Improve Industrial Engineering Practice in Costa Rican Industries

The following recommendations are concerned with the suggested approaches presented in Chapter V of this report concerning the improvement of Industrial Engineering practice in Costa Rican industries.

1. It is recommended that further studies be done on the feasibility and practicality of establishing an Industrial Engineering assistance office in Costa Rica for the purpose of providing advisory and field services, on a non-profit basis, to medium and small scale industries. In this respect, further investigation is required with regard to: (a) total number of companies interested in using the services of this agency, (b) specific sources of capital to finance this organization, (c) economic studies which could help to determine the cost of maintenance and operation, salary schedules for staff members, and fees to be charged for services rendered, (d) the type of personnel to be used for this purpose, and (e) the available international sources which could help to organize this institution. In the process of organizing this agency, it may be found that other areas, not mentioned here, may also require further research.

2. It is recommended that further studies be done on the feasibility and practicality of developing an Industrial Engineering educa-

tional program for non-Industrial Engineering personnel. In this respect, further investigation is required with regard to: (a) number of companies interested in participating, (b) type of courses to be offered, (c) educational institutions capable to organize this program, (d) type of personnel required to conduct these courses, and (e) necessary funds to finance this program and the fees to be charged to the participating firms. Once the program has been instituted, continuous research must be done with regard to the effectiveness of the program and the updating of the courses to be offered.

3. It is recommended that a re-evaluation be done of the Industrial Engineering cirriculum of the University of Costa Rica in order to adapt it to the needs of the country's industry. In this respect, further investigation is required with regard to: (a) areas of greatest need among the country's manufacturing sector, (b) the feasibility to introduce field practice as part of the educational program, and (c) areas of potential research (directly related to the needs of the country's industry) to be pursued by the students. Once the curriculum has been revised, investigation must continue to update the educational program as required by the country's industrial development.

Final Word

It has not been the purpose of this study to criticize the operational efficiency of Costa Rican industries or to imply that the use of Industrial Engineering in developing economies will make the industries problem-proof. The researcher's only intention was to analyze the uses and needs of Industrial Engineering in the country and based on this information and on the experiences of Georgia industries to recommend

ways to improve Industrial Engineering practice in the country's manufacturing sector as a means to accelerate the process of industrial development.

APPENDIX A

COSTA RICAN SURVEY

Exhibits

Tables

SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING

Atlanta, Georgia 30332 R. N. Lehrer, Director (404) 894-2300

Exhibit 1.

Estimado Senor:

Por este medio deseo solicitar su ayuda en relacion a un estudio que estoy preparando bajo los auspicios de la Organizacion de Estados Americanos sobre las posibles aplicaciones y usos de la Ingenieria Industrial en Costa Rica.

Los objectivos principales de esta investigacion son: (1) determinar la necesidad que el pais tiene de Ingenieros Industriales, (2) analizar la participacion y los beneficios que este tipo de profesionales pueden brindar al gobierno y a la industria privada, (3) proveer al empresario costarricense con un criterio que lo ayude a determinar la posible necesidad de los servicios de un Ingeniero Industrial en su firma, y (4) estudiar la factibilidad de una oficina asesora en el campo de la Ingenieria Industrial destinada exclusivamente a asistir a la industria privada sin fines lucrativos.

Para analizar los objectivos descritos anateriormente, ha sido necesario llevar a cabo una investigacion de la industria costarricense y norteamericana, con el fin de poder determinar y projectar la aplicabilidad de esta rama de la ingenieria en diferentes tipos y tamanos de industrias. Por esta razon me dirijo a Usted para solicitarle su colaboracion y el valor de su experiencia contestando unas preguntas concernientes a este estudio. Le agradeceria regresar el cuestionairo en el sobre que he incluido tan pronto sea de su conveniencia.

Los resultados de esta investigacion seran presentados al departamento de Ingenieria Industrial de el Instituto Tecnologico de Georgia y al Ministerio de Industria y Comercio de Costa Rica para su posible publicacion.

Atentamente,

Ing. Jorge Brealey.

SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING

Atlanta, Georgia 30332 R. N. Lehrer, Director (404) 894-2300

Exhibit 2.

USOS Y APLICACIONES DE LA INGENIERIA INDUSTRIAL
EN
COSTA RICA

La informacion que su compania pueda sumi nistrar por medio de este cuestionario servira para investigar los posibles usos y aplicaciones de la Ingenieria Industrial en el pais y para establecer un criterio que ayude al empresario costarricense a justificar, si es necesario, el uso de Ingenieros Industriales y a determinar los beneficios que estos pueden traer a su industria. Para el exito de este estudio se le agradece que conteste el mayor numero de preguntas concernientes a su empresa.

1. TIPO DE INDUSTRIA
   ( ) Textil
   ( ) Productos Alimenticios
   ( ) Productos Quimicos o sus derivados
   ( ) Productos de Plastico o de Metal
   ( ) Otro. _____

2. NUMERO APROXIMADO DE EMPLEADOS _____

3. VENTAS ANUALES ¢ _____

4. CUENTA SU FIRMA CON LOS SERVICIOS DE INGENIEROS INDUSTRIALES?
   ( ) Si. ( ) No.

5. HA USADO SU COMPANIA SERVICIOS DE CONSULTORIA EN LA RAMA DE LA INGENIERIA INDUSTRIAL?
   ( ) Nunca
   ( ) Pocas Veces
   ( ) Con Frecuencia.

6. HA RECIBIDO SU FIRMA EN ALGUNA OCASION ASESORIA DE EL DEPARTAMENTO DE INGENIERIA INDUSTRIAL DE EL MINISTERIO DE INDUSTRIA Y COMERCIO?
   ( ) Si
   ( ) No

7. SU SU COMPANIA NO TIENE INGENIEROS INDUSTRIALES Y NO USA SERVICIOS DE CONSULTORIA; POR FAVOR INDIQUE LAS RAZONES PRINCIPALES.
   ( ) El costo de los servicios es muy alto
   ( ) La gerencia no los considera necesrios
   ( ) No se ha definido la funcion que el Ingeniero Industrial puede tener en nuestra empresa.
   ( ) El numero de Ingenieros Industriales en Costa Rica es muy limitado
   ( ) Otra Razon _____

8. SI SU COMPANIA CUENTA CON LOS SERVICIOS DE INGENIEROS INDUSTRIALES O USA SERVICIOS DE CONSULTORIA; CUALES CONSIDERA USTED HAN SIDO LAS MAYORES CONTRIBUCIONES DE ESTOS PROFESIONALES A SU INDUSTRIA.
   ( ) Reducion de costos
   ( ) Mejora de metodos de produccion
   ( ) Mejora en control de la calidad de el producto
   ( ) Estudios de factibilidad
   ( ) Mejora en eficiencia laboral
   ( ) Asistencia a la gerencia
   ( ) Otra _____

9. SI UNA OFICINA ASESORA EN EL CAMPO DE LA INGENIERIA INDUSTRIAL SE CREARA PARA ASISTIR A LA INDUSTRIA PRIVADA SIN FINES LUCRATIVOS; ESTARIA USTED INTERESADO EN USAR SUS SERVICIOS?
   ( ) Si
   ( ) No

10. BAJO LA SUPERVISION DE CUAL DE LAS SIGUIENTES INSTITUCIONES CONSIDERA USTED QUE DICHA OFICINA DEBE FUNCIONAR?
   ( ) Ministerio de Industria y Comercio
   ( ) Camara de Industrias de Costa Rica
   ( ) Otra institucion _____

11. EN SU OPINION, SI ESTA OFICINA SE CREARA, COMO DEBE SER FINANCIADA?
   ( ) Por el Ministerio de Industria y Comercio
   ( ) Cobrando a las industrias por los servicios prestados
   ( ) Otra forma _____

12. LAS SIGUIENTES SON UNA SERIE DE ACTIVIDADES NORMALMENTE ASIGNADAS A INGENIEROS INDUSTRIALES. POR FAVOR INDIQUE LAS COLUMNAS RESPECTIVAS, QUIEN EJECUTA ESTAS FUNCIONES EN SU COMPANIA.

ASIGNADAS A ----------→	Industrial Engineer	Gerencia	Otras personas	No se Practican
Analisis de Costos de Produccion				
Planeamiento de la Produccion				
Diseno de Metodos de Produccion				
Diseno y Distribucion de Planta				
Analisis de Control de Calidad				
Analisis de Control de Inventarios				
Evaluacion y Costo Laboral				
Estudios de Reduccion de Costos				
Estudios de Tiempo (Time Studies)				
Programas de Prevencion de Accidentes				
Estudios de Factibilidad				
Estandards de Produccion				
Entrenamiento de Personal				
Programas de Incentivos Laborales				
Programas de Mantenimiento Preventivo				
Simplificacion de Metodos de Trabajo				
Diseno de Facilidades de Almacenamiento				
Asignamiento de Personal				
Programacion de Pedidos				
Distribucion de Materiales				

13. DE LAS ACTIVIDADES MENCIONADAS EN LA PREGUNTA 12, CUALES CONSIDERA USTED QUE ACTUALMENTE REPRESENTAN PROBLEMAS EN SU COMPANIA.

1. _____
2. _____
3. _____
4. _____
5. _____

14. TIENE SU COMPANIA EN PERSPECTIVA ALGUN ESTUDIO DE EXPANSION PROJECTABLE A LOS PROXIMOS CINCO ANOS?

( ) Si
( ) No

Table 1-A. Distribution of Questionnaire Returns. (June 1, 1975)

1. Distribution of Returns by Industry Type.

Type of Industry	Number of Returns	% of total Returns
Textiles	10	14.3
Food & Kindred Prod.	14	20.0
Plastic & Metal Ind.	15	21.4
Chemical & Allied Prod.	17	24.3
Miscellaneous	14	20.0
TOTAL	70	100.0

2. Distribution of Returns by Company Size.

Size of the Company (Number of Employees)	Number of Returns	% of Total Returns
50 to 100	16	22.9
100 to 200	32	45.8
200 to 400	12	17.0
400 to 600	7	10.0
More than 600	3	4.3
TOTAL	70	100.0

3. Total Response Rate.

Number of Questionnaire Returns	70
Total Response Rate	70%

Table 2-A. Distribution of Companies with Industrial Engineering Staffs.

1. Distribution by Industry Type.

Type of Industry	Number of Companies With I.E.	% of Total
Textiles	2	10.0
Food & Kindred Prod.	3	15.0
Plastic & Metal Ind.	4	20.0
Chemical & Allied Prod.	5	25.0
Miscellaneous	6	30.0
TOTAL	20	100.0

2. Distribution by Company Size.

Size of the Company (Number of Employees)	Number of Companies with I.E.	% of Total
50 to 100	4	20.0
100 to 200	7	35.0
200 to 400	5	25.0
400 to 600	2	10.0
More than 600	2	10.0
TOTAL	20	100.0

3. Total Number of Companies with I.E. Staffs

Number of Companies	20
Percentage of Total Returns	28.6%

Table 3-A. Distribution of Companies Using Industrial Engineering Consulting Services. (All Respondents)

1. Distribution by Industry Type

Type of Industry	Number of Companies	% of Total
Textiles	7	21.2
Food & Kindred Prod.	5	15.1
Plastic & Metal Ind.	7	21.2
Chemical & Allied Prod.	5	15.1
Miscellaneous	9	27.4
TOTAL	33	100.0

2. Distribution by Company Size

Size of the Company (Number of Employees)	Number of Companies	% of Total
50 to 100	6	18.1
100 to 200	20	60.0
200 to 400	5	15.1
400 to 600	1	3.4
More than 600	1	3.4
TOTAL	33	100.0

3. Total Distribution of Companies Using I.E. Consulting Services.

Total Number of Companies Using Consulting Services	33
Percentage of Total Returns	47.1%

Table 4-A. Distribution of Companies Using Only Industrial Engineering Consulting Services. (Companies Without Industrial Engineering Staffs)

1. Distribution by Industry Type.

Type of Industry	Number of Companies	% of Total
Textiles	5	27.7
Food & Kindred Prod.	3	16.6
Plastic & Metal Ind.	3	16.6
Chemical & Allied Prod.	5	27.7
Miscellaneous	2	11.4
TOTAL	18	100.0

2. Distribution by Company Size

Size of the Company (Number of Employees)	Number of Companies	% of Total
50 to 100	2	11.4
100 to 200	13	72.0
200 to 400	3	16.6
400 to 600	0	0.0
More than 600	0	0.0
TOTAL	18	100.0

3. Total Distribution of Companies Using I.E. Consulting Services (Companies without I.E. Staffs)

Number of Companies Using Consulting Services	18
Percentage of Total Number of Companies Without I.E. Staffs	34.0%

Table 5-A. Consulting Assitance Provided by the I.E. Office of the Department of Industry.

(Question 6: Have you ever receive consulting assistance from the I.E. office of the Department of Industry?)

1.	Companies Answering yes.	1
	Percentage of total returns	1.3%
2.	Companies Answering no.	69
	Percentage of total returns	98.7%

Table 6-A. Reasons for not Utilizing Industrial Engineering Services. (Companies without I.E. Staffs)

(Question 7: If you have never use Industrial Engineering services, please indicate the reasons)

Reasons	Number	% of Total Companies
1. Too Costly	2	6.3
2. Management Indifference	5	15.6
3. Have not justified the function of Industrial Engineers in the firm.	21	66.5
4. Not enough Industrial Engineers in Costa Rica	2	6.3
5. Other reasons	2	6.3
TOTAL	32	100.0

Table 7-A. Contributions from the Use of Industrial Engineering Services.

(Question 8: If your company has Industrial Engineers or uses consulting services, what do you consider have been the main contribution of these professionals to your firm?)

Major Contributions	Number of Responses	% of total Responses
Cost Reduction	10	16.4
Productivity Improvement	15	24.6
Quality Control	8	13.2
Labor Efficiency	5	8.2
Feasibility Studies	8	13.1
Assitance to the management in decision making	14	22.9
Other	1	1.6
TOTAL	61	100.0

Table 8-A. Management's Reactions and Opinions Concerning the Creation of an I.E. Assistance Office in Costa Rica.

(Questions 9: If a non-profit consulting office in the field of I.E. could be established in Costa Rica, would you be interested in using its services/)

Category	Number of Companies	% of otal Returns
Companies Interested	58	82.8
Companies not interested	12	17.2

(Question 10: Who do you feel should coordinate this office?)

Institution to Coordinate the Office	Number of Responses	% of Total Responses
Chamber of Industry	45	64.3
Department of Industry	16	22.8
Combination of the above two institutions	6	8.6
Other institutions	3	4.3

(Question 11: How do feel that this office should be financed?)

Financed By	Number of Responses	% of Total Responses
Department of Industry	12	17.1
With the revenues from services rendered	51	72.8
A mixture of both of the above	7	10.1

Table 9-A. Use of Industrial Engineering Techniques and Personnel Responsable for their Performance. (Companies with Industrial Engineering Staffs)

(Question 12: Below there is a list of activities normally performed by Industrial Engineers· please indicate if each of these activities is being performed in your firm and the type of personnel responsable for it)

I.E. Activity	Industrial Engineer		Management		Other Persons		Not Perform	
	#	%	#	%	#	%	#	%
Production Cost Analysis	5	25.0	15	75.0	10	50	0	0.0
Production Planning and Forecasting	9	45.0	7	35.0	10	50	0	0.0
Design of Prod. Processes	13	65.0	0	0.0	6	30	2	10.0
Production Standards	14	70.0	4	20.0	4	20	1	5.0
Labor Cost & Performance	9	45.0	5	25.0	7	35	3	15.0
Manpower Allocation	8	40.0	6	30.0	12	60	0	0.0
Labor Training	7	35.0	3	15.0	11	55	2	10.0
Time Studies & Standards	11	55.0	0	0.0	2	10	8	40.0
Labor Incentive Programs	10	50.0	8	40.0	5	25	1	5.0
Plant Facilities & Layout	14	70.0	1	5.0	5	25	1	5.0
Storage Facilities Design	14	70.0	1	5.0	2	10	4	20.0
Feasibility Studies	10	50.0	12	60.0	8	40	0	0.0
Accident Prevention	6	30.0	1	5.0	13	65	1	5.0
Preventive Maintenance	7	35.0	0	0.0	13	65	4	20.0
Inventory Control	7	35.0	3	15.0	14	70	0	0.0
Quality Control	7	35.0	0	0.0	13	65	1	5.0
Materials Handling	4	20.0	0	0.0	14	70	0	0.0
Scheduling & Dispatching	6	30.0	0	0.0	13	65	0	0.0
Cost Reduction Studies	19	95.0	5	25.0	7	35	1	5.0
Work Simplification	15	75.0	1	5.0	6	30	2	10.0

#: Number of Responses
%: Percentage of Total Number of Companies with Industrial Engineering Staffs. (20)

Table 10-A. Use of Industrial Engineering Techniques and Personnel Responsable for their Performance. (Companies without Industrial Engineering Staffs)

(Question 12: Same as Table 9-A)

I.E. Activity	Industrial Engineer *		Management		Other Persons		Not Perform	
	#	%	#	%	#	%	#	%
Production Cost Analysis	0	0.0	34	68.0	19	38	2	4.0
Production Planning and Forecasting	0	0.0	29	58.0	28	56	2	4.0
Desing of Prod. Processes	0	0.0	16	32.0	27	54	8	16.0
Production Standards	0	0.0	19	38.0	29	58	8	16.0
Labor Cost & Performance	0	0.0	16	32.0	20	40	18	32.0
Manpower Allocation	0	0.0	3	6.0	47	94	0	0.0
Labor Training	0	0.0	6	12.0	36	72	10	20.0
Time Studies & Standards	0	0.0	1	2.0	7	14	42	84.0
Labor Incentive Programs	0	0.0	28	56.0	14	28	11	22.0
Plant Facilities & Layout	8	16.0	12	24.0	27	54	8	16.0
Storage Facilities Design	0	0.0	3	6.0	21	42	31	62.0
Feasibility Studies	9	18.0	28	56.0	3	6	10	20.0
Accident Prevention	0	0.0	8	16.0	21	42	31	62.0
Preventive Maintenance	0	0.0	7	14.0	21	42	25	50.0
Inventory Control	0	0.0	25	50.0	24	48	6	12.0
Quality Control	0	0.0	16	32.0	33	66	18	36.0
Materials Handling	0	0.0	3	6.0	42	84	14	28.0
Scheduling & Dispatching	0	0.0	2	4.0	45	90	3	6.0
Cost Reduction Studies	0	0.0	23	46.0	29	58	6	12.0
Work Simplification	3	6.0	12	24.0	34	68	12	24.0

* Industrial Engineering Consulting Services
\# Number of Responses
% Percentage of the Total Number of Companies without Industrial Engineering Staffs. (50)

Table 11-A. Reported Operational Problems Experienced by Costa Rican Industries.

(Question 13: Of the Activities mentioned in question 12, which ones do you consider that represent the most critical problems in your company)

Problem Areas (Companies with I.E. Staffs)	Industry Type: Textiles		Metal and Plastic Products		Food and Kindred Products		Chemical and Allied Prod.		Miscellaneous Manufacturing Enterprises		Company Size (Number of Employees): 50-100		100-200		200-400		400-600		More Than 600	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Cost Analysis	1	5.0	2	10.0	0	0.0	1	5.0	0	0.0	1	5.0	2	10.0	1	5.0	0	0.0	0	0.0
Production Planning	0	0.0	1	5.0	0	0.0	0	0.0	2	10.0	1	5.0	1	5.0	1	5.0	0	0.0	0	0.0
Production Methods	0	0.0	1	5.0	0	0.0	2	10.0	1	5.0	0	0.0	1	5.0	1	5.0	1	5.0	1	5.0
Quality Control	1	5.0	3	15.0	0	0.0	1	5.0	2	10.0	2	10.0	2	10.0	2	10.0	1	5.0	0	0.0
Inventory Control	1	5.0	3	15.0	1	5.0	2	10.0	1	5.0	1	5.0	2	10.0	4	20.0	1	5.0	0	0.0
Labor Efficiency	0	0.0	2	10.0	1	5.0	0	0.0	4	20.0	1	5.0	1	5.0	4	20.0	0	0.0	1	5.0
Cost Reduction	0	0.0	3	15.0	0	0.0	1	5.0	4	20.0	2	10.0	2	10.0	3	15.0	0	0.0	1	5.0
Labor Incentives	0	0.0	2	10.0	0	0.0	0	0.0	2	10.0	0	0.0	1	5.0	3	15.0	0	0.0	0	0.0
Preventive Maintenance	0	0.0	0	0.0	1	5.0	0	0.0	1	5.0	0	0.0	0	0.0	2	10.0	0	0.0	0	0.0
Work Simplification	0	0.0	0	0.0	0	0.0	0	0.0	2	10.0	0	0.0	0	0.0	1	5.0	0	0.0	1	0.0
Feasibility Studies	0	0.0	0	0.0	0	0.0	1	5.0	1	5.0	0	0.0	1	5.0	1	5.0	0	0.0	0	0.0
Problem Areas (Companies without I.E. Staffs)																				
Cost Analysis	5	10.0	1	2.0	7	14.0	7	14.0	5	10.0	3	6.0	15	30.0	4	8.0	2	4.0	1	2.0
Production Planning	5	10.0	6	12.0	1	2.0	4	8.0	2	4.0	1	2.0	13	26.0	1	2.0	1	2.0	1	2.0
Production Methods	0	0.0	4	8.0	1	2.0	3	6.0	3	6.0	3	6.0	3	6.0	3	6.0	1	2.0	1	2.0
Quality Control	4	8.0	5	10.0	0	0.0	3	6.0	2	4.0	0	0.0	9	18.0	3	6.0	1	2.0	1	2.0
Inventory Control	4	8.0	3	6.0	5	10.0	0	0.0	1	2.0	2	4.0	8	16.0	2	4.0	1	2.0	0	0.0
Labor Efficiency	6	12.0	5	10.0	8	16.0	10	20.0	5	10.0	5	10.0	15	30.0	8	16.0	6	12.0	0	0.0
Cost Reduction	3	6.0	5	10.0	3	6.0	5	10.0	3	6.0	5	10.0	9	18.0	4	8.0	1	2.0	0	0.0
Accident Prevention	0	0.0	2	4.0	0	0.0	0	0.0	1	2.0	3	6.0	0	0.0	0	0.0	0	0.0	0	0.0
Production Standards	0	0.0	0	0.0	2	4.0	0	0.0	1	2.0	0	0.0	2	4.0	1	2.0	0	0.0	0	0.0
Labor Incentives	2	4.0	6	12.0	3	6.0	2	4.0	2	4.0	4	8.0	6	12.0	4	8.0	0	0.0	1	2.0
Preventive Maintenance	3	6.0	2	4.0	2	4.0	9	18.0	3	6.0	6	12.0	8	16.0	3	6.0	0	0.0	0	0.0
Work Simplification	0	0.0	2	4.0	1	2.0	3	6.0	2	4.0	2	4.0	3	6.0	2	4.0	1	0.0	0	0.0
Feasibility Studies	3	6.0	2	4.0	7	14.0	3	6.0	3	6.0	4	8.0	9	18.0	2	4.0	2	4.0	1	2.0
Fac. Design & Layout	0	0.0	1	2.0	0	0.0	0	0.0	0	0.0	1	2.0	0	0.0	0	0.0	0	0.0	0	0.0

* Percentages based on the total number of responding companies within each group. (20 with I.E. Staffs. 50 without I.E. Staffs)

Table 12-A. Projected Expansion of Costa Rican Industries

(Question 14: Is your company projecting to expand its operations in the next five years?)

1. Response distribution by Industry Type.

Type of Industry	Number of Responses	% of responses within the type of industry
Textiles	9	90.0
Food & Kindred Prod.	14	100.0
Plastic & Metals Ind.	12	80.0
Chemical & Allied Prod.	12	71.0
Miscellaneous Enterprises	14	100.0

2. Response distribution by Company Size.

Size of Company (Number of Employees)	Number of Responses	% of responses within the group size
50 to 100	12	75.0
100 to 200	30	94.0
200 to 400	12	100.0
400 to 600	4	58.0
More than 600	3	100.0

3. Overall Response Distribution (All Respondents)

Companies Projecting to Expand	61
Percentage of Total Respondents	87.0

APPENDIX B

GEORGIA SURVEY

Exhibits

Tables

SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING

Atlanta, Georgia 30332 R. N. Lehrer, Director (404) 894-2300

Exhibit 1.

Dear Sir:

I would like to ask for your assistance in regard to a study that I am preparing on the applications and uses of Industrial Engineering in medium size industries.

I am a graduate student in the School of Industrial & Systems Engineering at Georgia Institute of Technology. In the process of finishing my graduate work, I am conducting an investigation to: (1) determine the contributions of Industrial Engineering activities in medium size industries, (2) define the most efficient use of Industrial Engineering applications in each type of industry investigated, and (3) formulate a criteria to assit management in justifying the need for Industrial Engineering services in their companies.

The School of Industrial & Systems Engineering of this university feels that the outcome of this investigation will be of very significant value not only for management but for the industry in general. For this reason I am requesting your assistance in completing a brief questionnaire that I have attached and then returning it in the enclosed postage-paid envelope.

Due to the importance of the feedback information in this type of study, I would appreciate that if for any reason you or any of your assistants are not able to answer the questionnaire, please just return it blank.

Your experience would be of great value to my research, and if you are interested in a copy of the results I would be glad to mail it to you if you so indicate on the questionnaire.

Sincerely yours,

Jorge E. Brealey

SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING

Atlanta, Georgia 30332 R. N. Lehrer, Director (404) 894-2300

Exhibit 2.

INDUSTRIAL ENGINEERING USES AND APPLICATIONS

It is the objective of this survey to investigate the uses and applications of Industrial Engineering in medium size industries. The results are expected to provide a criteria to assist management in identifying the need for Industrial Engineering services and the benefits to be drawn from them. Please answer all questions applicable to your firm.

1. TYPE OF INDUSTRY.
   ( ) Textiles
   ( ) Chemical and Allied Products
   ( ) Food and Kindred Products
   ( ) Plastic and Metal Products
   ( ) Other _____

2. APPROXIMATE NUMBER OF EMPLOYEES _____

3. APPROXIMATE ANNUAL SALES VOLUME $_____

4. DOES YOUR COMPANY HAVE A FULL TIME INDUSTRIAL ENGINEER?
   ( ) Yes. ( ) No.

5. DOES HE (OR THEM) HAVE A COLLEGE DEGREE IN INDUSTRIAL ENGINEERING?
   ( ) Yes. ( ) No.

6. WHAT TYPE OF ACTIVITIES IS HE DEDICATED TO?
   ( ) Industrial Engineering
   ( ) Other

7. HAS YOUR COMPANY EVER USED THE SERVICES OF A CONSULTING INDUSTRIAL ENGINEERING FIRM?
   ( ) Never
   ( ) Seldom
   ( ) Often

8. IF YOUR COMPANY IS A DIVISION OF A NATIONAL CORPORATION, DO YOU RECEIVE INDUSTRIAL ENGINEERING CONSULTING ASSISTANCE FORM THE CORPORATE STAFF?
   ( ) Never
   ( ) Seldom
   ( ) Often
   ( ) Not Applicable

9. IF YOUR COMPANY HAS NEVER USED THE SERVICES OF INDUSTRIAL ENGINEERS, PLEASE INDICATE THE REASONS FOR THIS.
   ( ) Too costly
   ( ) Management indifference
   ( ) Have not justified the function of Industrial Engineers in our company
   ( ) Is difficult to find Industrial Engineers
   ( ) Other _____

10. IF YOUR COMPANY HAS AN INDUSTRIAL ENGINEER (OR AN INDUSTRIAL ENGINEERING DEPARTMENT) OR USES INDUSTRIAL ENGINEERING CONSULTING SERVICES; WHAT DO YOU CONSIDER HAVE BEEN THE MAIN CONTRIBUTIONS FROM THESE PROFESSIONALS TO YOUR FIRM?
   ( ) Cost Reduction
   ( ) Productivity Improvement
   ( ) Product quality improvement
   ( ) Higher labor efficiency
   ( ) Cost Analysis
   ( ) Feasibility Studies
   ( ) Plant facilities and layout
   ( ) Labour incentives
   ( ) Assistance to the management in decision making
   ( ) Other_____

11. BELOW THERE IS A LIST OF ACTIVITIES NORMALLY PERFORMED BY INDUSTRIAL ENGINEERS. PLEASE INDICATE THE TYPE OF PERSONNEL PERFORMING EACH OF THESE ACTIVITIES IN YOUR COMPANY AFTER EACH COLUMN PROVIDED.

PERFORMED BY ----------→	Industrial Engineer	Other Personnel	Not Performed
Production Cost Analysis			
Production Planning and Forecasting			
Design of Production Processes			
Labor Performance and Cost			
Manpower Allocation			
Labour Training Programs			
Time Studies and Standards			
Labour Incentive Programs			
Plant Facilities and Layout			
Storage Facilities Design			
Expansion Feasibility Studies			
Accident Prevention Programs			
Preventive Maintenance Programs			
Inventory Control Policies			
Quality Control Methods			
Materials Handling			
Scheduling and Dispatching			
Cost Reduction Studies			
Work Simplification			
Production Standards			
Others			

12. IF YOU WOULD LIKE A COPY OF THE RESULTS OF THIS STUDY PLEASE INDICATE SO.

( ) I Would Like a Copy.
( ) I Would not Like a Copy.

THANK YOU FOR YOUR COOPERATION

Table 1-B. Distribution of Questionnaire Returns. (June 1, 1975)

1. Distribution of Returns by Industry Type.

Type of Industry	Number of Returns	% of total Returns
Textiles	21	26.9
Food & Kindred Prod.	16	20.5
Plastic & Metal Ind.	15	19.2
Chemical & Allied Prod.	15	19.2
Miscellaneous	12	14.2
TOTAL	78	100.0

2. Distribution of Returns by Company Size.

Size of the Company (Number of Employees)	Number of Returns	% of total Returns
50 to 100	N.A.	N.A.
100 to 200	21	26.9
200 to 400	27	34.3
400 to 600	17	22.2
More than 600	13	16.6
TOTAL	78	100.0

3. Total Response Rate.

Number of Questionnaire Returns	78
Total Response Rate	78%

Table 2-B. Distribution of Companies with Industrial Engineering Staffs.

1. Distribution by Industry Type.

Type of Industry	Number of Companies with I.E.	% of total
Textiles	20	37.0
Food & Kindred Prod.	10	18.5
Plastic & Metal Ind.	10	18.5
Chemical & Allied Prod.	9	16.6
Miscellaneous	5	9.4
TOTAL	54	100.0

2. Distribution by Company Size.

Size of the Company (Number of Employees)	Number of Companies with I.E.	% of total
50 to 100	N.A.	N.A.
100 to 200	10	18.5
200 to 400	18	33.3
400 to 600	14	25.9
More than 600	12	22.3
TOTAL	54	100.0

3. Total Number of Companies with I.E. Staffs.

Number of Companies	54
Percentage of Total Returns	69.2

Table 3-B. Educational Background of Industrial Engineering Practitioners in Georgia Industries.

(Question 5: Does your Industrial Engineer have a college degree in Industrial Engineering?)

Companies Answering Yes	35
Percentage of total number of companies with Industrial Engineers	64.8%
Companies Answering No	19
Percentage of total number of companies with Industrial Engineers	35.2%

Table 4-B. Type of Activities to which Industrial Engineers are Dedicated in Georgia Industries.

(Question 6: To what type of activities is your Industrial Engineer dedicated to?)

Type of Activities	Number of Responses	% of total
1. Industrial Engineering Activities	24	44.4
2. Other than Industrial Engineering	8	14.9
3. Industrial Engineering and other Type of Activities	22	40.7
TOTAL	54	100.0

Table 5-B. Distribution of Companies Using Industrial Engineering Consulting Services (All Respondents)

1. Distribution by Industry Type.

Type of Industry	Number of Companies	% of Total
Textiles	13	27.6
Food & Kindred Prod.	9	19.1
Plastic & Metal Ind.	7	14.9
Chemical & Allied Prod.	8	17.0
Miscellaneous	10	21.4
TOTAL	47	100.0

2. Distribution by Company Size.

Size of the Company (Number of Employees)	Number of Companies	% of Total
50 to 100	N.A.	N.A.
100 to 200	9	19.1
200 to 400	18	38.2
400 to 600	11	23.6
More than 600	9	19.1
TOTAL	47	100.0

3. Total Distribution of Companies Using I.E. Consulting Services.

Total Number of Companies Using I.E. Consulting Services	47
Percentage of Total Returns	60.3%

Table 6-B. Distribution of Companies Using Only Industrial Engineering Consulting Services. (Companies without I.E. Staffs)

1. Distribution by Industry Type.

Type of Industry	Number of Companies	% of Total
Textiles	0	0.0
Food & Kindred Prod.	3	20.0
Plastic & Metal Ind.	3	20.0
Chemical & Allied Prod.	3	20.0
Miscellaneous	6	40.0
TOTAL	15	100.0

2. Distribution by Company Size.

Size of the Company (Number of Employees)	Number of Companies	% of Total
50 to 100	N.A.	N.A.
100 to 200	7	46.6
200 to 400	6	40.0
400 to 600	1	6.7
More than 600	1	6.7
TOTAL	15	100.0

3. Total Distribution of Companies Using Only Consulting Services.

Number of Companies Using Only Consulting Services	15
Percentage of total Number of Companies without I.E. Staffs	62.5

Table 7-B. Distribution of Companies Receiving Industrial Engineering Assistance from Corporate Staffs.

1. Distribution by Industry Type.

Type of Industry	Number of Companies	% of Total
Textiles	6	16.6
Food & Kindred Prod.	8	22.5
Plastic & Metal Ind.	6	16.6
Chemical & Allied Prod.	10	27.7
Miscellaneous	6	16.6
TOTAL	36	100.0

2. Distribution by Company Size.

Size of the Company (Number of Employees)	Number of Companies	% of Total
50 to 100	N.A.	N.A.
100 to 200	17	47.2
200 to 400	8	22.5
400 to 600	5	13.7
More than 600	6	16.6
TOTAL	36	100.0

3. Total Distribution of Companies Receiving I.E. Assistance from Corporate Staffs.

Number of Companies Receiving I.E. Assistance from Corporate Staffs.	36
Percentage of Total Returns	46.1%

Table 8-B. Reported Reasons for not Using Industrial Engineering Services.

(Question 9: If your company have never used the services of Industrial Engineers, please indicate the reasons)

Reasons	Number of Responses	% of Total
1. Too Costly	1	11.1
2. Management Indifference	1	11.1
3, Have not justified the function of Industrial Engineers in the firm.	6	66.6
4. Other Reasons	1	11.1
TOTAL	9	100.0

Table 9-B. Contributions from the Use of Industrial Engineers.

(Question 10: If your company has Industrial Engineers or uses consulting services, what do you consider have been the main contributions from these professionals to your company)

Major Contribution	Number of Responses	% of Total Responses
Cost Reduction	39	21.9
Productivity Improvement	47	26.4
Quality Control	21	11.8
Labor Efficiency	33	18.5
Assistance to Management	33	18.5
Others	5	2.9
TOTAL	178	100.0

Table 10-B. Use of Industrial Engineering Techniques and Personnel Responsable for their Performance. (Companies with Industrial Engineering Staffs)

(Question 11: Below there is a list of activities normally performed by Industrial Engineers, please indicate if each of these activities is being performed in your firm and the type of personnel responsable for it)

I.E. Activity	Industrial Engineer		Other Personnel		Not Performed	
	#	%	#	%	#	%
Production Cost Analysis	37	68.8	34	63.1	0	0.0
Production Planning and Forecasting	27	50.3	33	61.2	0	0.0
Design of Prod. Processes	31	57.4	30	55.5	1	1.9
Production Standards	42	78.3	16	30.3	2	3.8
Labor Cost & Performance	44	82.1	18	34.1	1	1.9
Manpower Allocation	40	74.4	21	38.7	1	1.9
Labor Training	16	30.3	32	59.3	6	11.4
Time Studies and Standards	44	82.1	4	7.6	7	13.3
Labor Incentive Programs	30	55.5	11	20.8	14	26.5
Plant Facilities & Layout	44	82.1	20	37.8	0	0.0
Storage Facilities Design	18	34.1	8	15.2	2	3.8
Feasibility Studies	31	57.4	24	45.4	5	9.5
Accident Prevention	18	34.1	35	65.0	7	13.3
Preventive Maintenance	14	26.5	42	78.3	1	1.9
Inventory Control	13	24.4	43	80.2	1	1.9
Quality Control	17	32.2	40	74.4	0	0.0
Materials Handling	22	41.6	32	59.3	0	0.0
Scheduling & Dispatching	6	11.4	21	39.7	0	0.0
Cost Reduction Studies	44	82.1	16	30.3	1	1.9
Work Simplification	45	84.0	8	15.2	6	11.4

#: Number of Responses
%: Percentage of Total Number of Companies with Industrial Engineering Staffs (54)

Table 11-B. Use of Industrial Engineering Techniques and Personnel Responsable for their Performance. (Companies without Industrial Engineering Staffs)

(Question 11: Same as in Table 10-B)

I.E. Activity	Industrial Engineer *		Other Personnel		Not Performed	
	#	%	#	%	#	%
Production Cost Analysis	0	0.0	24	100.0	0	0.0
Production Planning and Forecasting	0	0.0	24	100.0	0	0.0
Design of Prod. Processes	1	4.1	16	65.6	7	28.7
Production Standards	1	4.1	22	91.8	1	4.1
Labor Cost & Performance	0	0.0	20	85.6	4	16.4
Manpower Allocation	0	0.0	24	100.0	0	0.0
Labor Training	0	0.0	22	91.8	2	8.2
Time Studies & Standards	2	8.2	14	57.4	8	32.8
Labor Incentive Programs	1	4.1	15	61.5	8	32.8
Plant Facilities & Layout	4	16.4	18	73.8	2	8.2
Storage Facilities Design	0	0.0	12	50.0	12	50.0
Feasibility Studies	6	24.6	13	54.1	5	20.5
Accident Prevention	0	0.0	22	91.8	2	8.2
Preventive Maintenance	0	0.0	23	95.9	1	4.1
Inventory Control	1	4.1	22	91.8	1	4.1
Quality Control	2	8.2	20	85.6	2	8.2
Materials Hanling	2	8.2	22	91.8	0	0.0
Scheduling & Dispatching	0	0.0	24	100.0	0	0.0
Cost Reduction Studies	2	8.2	20	85.6	2	8.2
Work Simplification	2	8.2	17	69.7	5	20.5

*: Consulting Services
#: Number of Responses
%: Percentage of Total Number of Companies without I.E. Staffs

APPENDIX C

CASE HISTORY ABSTRACTS

CASE STUDY ABSTRACT

COMPANY NO. 1

Background

This company is located in the outskirts of San Jose, (capital city of Costa Rica). As part of the food industry, this firm has been in existence for over 10 years. Despite several setbacks during its development, the company is now well established with a sizeable share of the domestic and Central American markets. The company employs approximately 250 persons, about two-thirds of whom are production workers. Its products include a variety of items of which the most important are cookies and candy products. Manufacturing facilities are attractive and well maintained and production processes appear to be well designed. The owner-manager maintains close operating controls over all phases of management and retains authority for planning and decision-making. Financial management controls seem to be well developed; management had good knowledge of the balance of internal costs and had been able to recognize those products and processes which were marginal. As in most food industries, plant maintenance was closely related to quality control. Quality standards were high and product quality was under continuous surveillance by the company's own quality control technician as well as by government inspectors. In the past, this company used the services of Industrial Engineers in designing the plant and in revising and improving production methods. At the present time the company does not use the assistance of Industrial Engineers.

Problems and Needs

Perhaps the most significant factor to be considered in viewing this company is the criticality of manpower problems within the organization. In swift order, the manager-owner described his personnel problems as including very poor productivity, high absenteeism and turnover, low employee morale, low employee skills and unusual training needs. It was difficult to determine just where to begin in analyzing the personnel needs of the firm. An evaluation of the company's labor policies and work practices revealed that for the most part, manpower difficulties had originated from lack of work training methods, poor management-labor relations, unefficient administration of incentive programs and essentially, from the non-existence of personnel capable of coping with these type of problems.

Most of the employee's learning was found to be done on the job and in most cases, workers were not instructed as to safety precautions which often resulted in human accidents and equipment breakdowns. Another characteristic of the training practices of this firm was that, in most cases, only one person was taught how to operate each piece of equipment meaning that when that specific worker was absent from the job, the machine was forced to be idle. With the purpose of increasing the productivity per person, the manager had established an incentive program based on a bonus (money) at the end of each year for those workers who showed to be highly productive. The task of choosing these workers was given to the plant manager, however, the lack of standard procedure for choosing these persons created misunderstandings and friction between labor and management. One machine operator summarized the results of

this incentive program in the following words "the bonus always goes to department heads or to friends of the plant manager, so it does not matter if we do a good job or not." In conclusion, the incentive program was causing more damage to employee's morale than benefit to the company. As to why the owner did not get any feedback of the negative results of the program, can be explained by the lack of communication channels between workers and management. The owner was too busy with his duties and responsibilities and no labor-management relation programs had been established.

Conclusions of Case Study

This company was an excellent example of many case study firms, as manpower problems were concerned. The investigation of the company's labor policies, work methods and incentive programs served to show that the problems of personnel were real and in critical need for solutions. Manpower activities were the most frequent problem of Costa Rican industries (as confirmed by survey results), however, with a few exceptions, management does not have the necessary knowledge or background required to cope with these problems. Generally speaking, it was understandable that full-scale personnel programs would be difficult and expensive to administer in many Costa Rican firms, however, due to the nature of the problems, it would be beneficial for many of these companies to consider the use of advisory services from professional personnel capable of coping with these type of difficulties.

CASE STUDY ABSTRACT

COMPANY NO. 2

Background

This company is part of the zipper industry in Costa Rica. The firm has been in operation for over 10 years and currently employs between 200 and 250 persons. The management staff is small and the president - part owner retains all planning, coordinating and decision-making responsibilities. The firm sells finished zippers to retailers and zipper parts to other manufacturers in the country and in the Central American area. The production process was lately revised and new equipment was acquired with the objective to increase productivity. The plant facilities are attractive and well maintained. The company has good potential for future development and for expansion to foreign markets.

Problems and Needs

Personnel

This firm, as case study company # 1, is currently experiencing large difficulties in the area of manpower utilization and efficiency, however, these problems will not be discussed in this abstract because they were already analyzed in detail in the previous case study investigation.

Manufacturing

The primary problems of manufacturing which now confronts the company include the following:

1. The need for improving quality control methods.
2. The need for establishing inventory control policies.
3. The need for revising plant layout and materials handling problems.
4. The need for improving production process flow.
5. The need for establishing production planning policies.

Quality control was perhaps the most critical problem in the organization. A 1-0 per cent inspection method (prior to packing the final product) had been used for the past two years. Defective units allowed the possibility to be repaired but at high cost to the company. The manager was aware of the excessive losses resulting from the high number of defective product, however, no action had been taking in evaluating the existing program or in searching for new quality control methods.

Inventory control was another problem to the firm. The lack of basic inventory control policies had resulted in the company not being able to meet many orders (for zippers), and in some instances even loosing some of these orders. Here again no attempt had been made to cope with the inventory control problem.

As a result of recent expansion in plant facilities, the production process had been altered. An intermediate manufacturing phase had been located in addition to the plant which was built across the street from the main facilities. This obviously created an excess of material handling problems and resulted in an interrupted production flow.

Production planning policies were non-existent in this firm. The company's decision was to produce against incoming orders. This together

with the lack of inventory control programs resulted in high operational inefficiency and unnecessary manufacturing costs.

Financial Management

In the area of cost analysis, it was found that management was able to recognize that some of the manufacturing operations and company's practices were being unprofitable, however, they were unable to determine the specific sources of excess costs.

Conclusions of Case Study

This company helped to illustrate the nature and causes of some of the most common problems reported by Costa Rican industries (in the questionnaire survey). Throughout the detailed investigation of the company's operational and organizational procedures it became evident, that a majority of the problems had originated from the lack of basic techniques available for coping with these problems. In realizing that some difficulties experienced by this company and many case study firms could be solved by Industrial Engineering applications, the results of the investigation served to confirm the need for this professional practice within the Costa Rican industry.

CASE STUDY ABSTRACT

COMPANY NO. 3

Background

This company is less than 5 years old and relatively small (50 persons). The management staff consisted of two persons, a president-owner and a production manager. Its products are mainly cosmetics and beauty items. The plant facilities are small but well designed. The equipment used in the production process is modern and well maintained. The company is notable for several things: it is young, very successful and was planned with a degree of care and foresight, unusual in small businesses. During the early stages of development (first year), the firm used the services of Industrial Engineering consultants to assist in the design of production facilities and to help the owner in the selection of manufacturing equipment. For the past four years, no outside assistance has been used. In responding to the questionnaire survey, this company reported that the services of Industrial Engineers at the present time were not justified within the firm.

Problems and Needs

Throughout the detailed investigation of the operational and organizational practices of the firm, the observer was able to conclude that for the most part, the existing problems in this establishment were not significant enough to justify the expense of hiring an Industrial Engineer. The above conclusion by no means implies that there were not manufacturing and organizational areas within the company which required improvement and refinement. However, the size of the firm and the

and the magnitude of the existing problems made it economically unprofitable at this stage of industrial development to pay for outside assistance (basically because of the high cost of advisory services in Costa Rica).

In an interview with the president of the company, the owner acknowledged the fact that it would be beneficial for the firm to have the assistance of professionals with the necessary knowledge and experience in solving the type of problems that existed in his company, but he felt that the company was not in the position at that time to justify the expense involved in obtaining these services.

Conclusions of Case Studies

This company, which is representative (in size) of a large portion of the Costa Rican manufacturers, helped to illustrate the fact that many firms in the country do not use Industrial Engineering or other professional services not because they do not consider them necessary but more likely because it is economically unprofitable for establishments of this size to pay for outside advisory services.

Perhaps, if the professional assistance could be provided to medium and small-scale manufacturers on a non-profit basis, they will be inclined to use this service more often.

CASE STUDY ABSTRACT

COMPANY NO. 4

Background

This company is part of the plastic products industry in Costa Rica. The firm has been in existence for more than 12 years and currently employs approximately 200 persons. The company has been closely controlled with most authority retained in the hands of the manager-owner. The firm is family held (which is typical of many Costa Rican industries) and several members of the family are part of the management staff. Manufacturing facilities are not modern but they are well maintained. Production methods are traditional and financial management is handled by two accountants who seem to be doing an efficient job.

This company, as case study firm # 3, reported on the questionnaire form that the services of Industrial Engineers were not justified within the establishment.

Problems and Needs

In contrast to case study company # 3, this firm was relatively larger and fully established. During recent years in order to compete with the new industries in the area of plastic products, the manager-owner had increased the production capacity of the company by acquiring additional manufacturing equipment and by increasing the number of production workers. However, the expansion plans did not call for an increase in management or technical staffs. The new production practices led to a number of operational problems which are commonly

experienced by larger firms. These problems will not be discussed here because they were already analyzed in detail in case study firms # 1 and # 2. Some of these common difficulties were found in areas related to cost analysis, production planning, personnel activities, quality control, inventory control and equipment layout.

In an extensive interview with the company manager and staff members, the observer pointed out the significance of some of the existing problems in the organization. Furthermore, he explained to them the potential benefits of using professional advisory services in coping with these problems. However, by the reactions of the management staff to these comments, it became evident that due to their limited knowledge of Industrial Engineering applications they felt that Industrial Engineers could be of no assistance to the firm in solving the existing problems.

Conclusions of Case Study

The importance of this case study lies on the fact that it helped to illustrate a common attitude found among a number of Costa Rican manufacturers. Even though, they are aware of the problems of their organization and of their causes, their lack of awareness concerning professional practices prevents them from justifying the need for these professional services (this was confirmed in the case study investigations for the case of Industrial Engineering).

This company, together with case study firm # 3, served to provide a better interpretation as to why many participants in the questionnaire survey reported that they did not justify the need for Industrial

Engineers. Furthermore, these investigations confirmed the fact that there is a need not only to provide assistance to medium and small-scale industries at a lower cost but also to educate managers and company officials on the uses and benefits of Industrial Engineering practices.

CASE STUDY ABSTRACT

COMPANY NO. 5

Background

This company is an excellent example of rapid growth. Located in one of the metropolitan areas of Costa Rica, the firm actually employs 577 persons, two-thirds of whom are production workers. The company has been in operation for less than 10 years and as part of the rubber industry (tire manufacturer) in Costa Rica, it covers most of the domestic market plus a large portion of the Central American market. Manufacturing facilities are ideal and production methods were found to be highly efficient. The company maintains more formal systems of inventory control and quality control than most of the manufacturing establishments in the country. Its manager (an Industrial Engineer himself) is responsible for decision-making, however, he has delegated a great deal of authority to his technical and management staffs. In the third year of operation, the firm acquired the services of an Industrial Engineer (in addition to the manager) and today the company counts with an Industrial Engineering department with a staff of two Industrial Engineers and a quality control technician.

Application of Industrial Engineering Techniques

The importance of viewing this company is that it helped to illustrate how Industrial Engineering skills could be utilized in solving and in some instances preventing many of the problems commonly found among Costa Rican industries.

Manufacturing

Some of the responsibilities of the Industrial Engineering department in the area of manufacturing activities were: coordination of production programs, establishment and revision of production control programs, improvement of manufacturing methods, simplification of production practices and conduction of manufacturing feasibility studies. In addition to this, the department was responsible for assisting and advising other departments in activities related to inventory control systems, cost study analysis and quality control programs.

In coordinating production activities, the Industrial Engineer was responsible for establishing efficient communication channels among production department heads in order to minimize errors due to misunderstandings. By establishing and reviewing production control programs, this practitioner made sure that production planning and scheduling was done efficiently. He coordinated the actions required to correct problems occurring during manufacturing processes and determined the most efficient and economical methods of production. In addition to the previous two functions, the Industrial Engineer in this company was involved in determining the raw materials and purchased parts required to support in-house fabrication. Activities related to design of production methods and improvement of working practices were found to be highly related to production control programs. Finally, in the area of manufacturing, the Industrial Engineer was in charge of conducting product feasibility studies and help the management in decision-making.

Personnel

Some of the responsibilities of the Industrial Engineering department

in the area of personnel activities were identified by the manager as including: out of the job training programs, administration and evaluation of labor incentives, coordination of labor-management relation programs and evaluation of manpower requirements.

Training programs were conducted by Industrial Engineers with the assistance of company's foremen. These training courses were offered periodically and they were followed by evaluation on the job. In the area of labor incentives, the Industrial Engineer (in conjunction with the manager) was responsible for the administration of various incentive programs intended to achieve higher productivity per person and create good employee's morale. The results of these programs were evaluated on a periodical basis for the purpose of determining their effectiveness. With regard to labor-management relation programs, the Industrial Engineer in this company was the link between workers and management staff. In addition when both parties had requested, he had served as a mediator in labor-management disputes.

Financial Management

Considering the investment involved in manufacturing facilities and production materials, the manager felt that it was particularly important to refine cost controls and establish specific cost analysis to pinpoint the more costly areas. These two functions had been assigned in this company to the Industrial Engineering staff, who by working together with the financial department was able to provide the management with efficient methods for cost control.

Conclusions of Case Study

This case study served to illustrate that without the use of sophisticated quantitative techniques, the Industrial Engineer can be of great benefit to developing industries. Furthermore, it helped to confirm the assumption that a large amount of problems commonly found among Costa Rican manufacturers could be solved and even prevented by the use of Industrial Engineering techniques. While the company was not problem-proof, it was a good example of a highly efficient organization, and this could be attributed to the manager's eagerness and willingness to use various types of professional services in solving and preventing operational and organizational problems within the company.

APPENDIX D

Exhibits

1. Projected Number of Graduate Industrial Engineers Of the University of Costa Rica (1975-1979)
2. Present Industrial Engineering Curriculum of the University of Costa Rica (1975)

4 de marzo de 1975
N° EII-031-75 E.

Señor
Jorge E. Brealey
Georgia Institute of Technology
P.O. Box 32699

Estimado señor:

En días pasados el Ing. Rodrigo Orozco me pasó su nota en la cual le solicita algunos datos de la carrera de Ingeniería Industrial para su tesis profesional.

A continuación le suministro los datos que usted necesita:

La Escuela de Ingeniería Industrial se estableció en Julio de 1971; han egresado treinta y dos (32) estudiantes a diciembre de 1974 y actualmente cuenta con ciento veinte (120) alumnos, para el futuro se proyectan las siguientes cifras de graduación:

1975	25
1976	30
1977	35
1978	40
1979	50

La Universidad de Costa Rica por medio de la Facultad de Ingeniería establece los programas de Ingeniería Industrial de acuerdo a las reuniones de Asamblea de Escuela la que cuenta con once profesores de los cuales cinco son Bachilleres, cuatro tienen Maestría y dos son doctores.

Sin otro particular saluda atentamente,

Dr. Pedro J. Rey Merino
DIRECTOR

cc.:Archivo

PROGRAMA MODELO
BACHILLERATO EN INGENIERIA
Primeros cuatro semestres comunes para las carreras
de Ingeniería Eléctrica, Industrial y Mecánica

Primer Semestre		HC	HL	CR
EG-1	Castellano	2	0	0
EG-2	Filosofía	2	0	0
EG-3	Historia	2	0	8
Q-102M	Química I	4	0	3
MA-201	Cálculo I	4	1	4

Segundo Semestre		HC	HL	CR
EG-1	Castellano	2	0	0
EG-2	Filosofía	2	0	0
EG-3	Historia	2	0	8
Q-103M	Química II	4	0	3
FS-201	Física I	4	0	4
MA-301	Cálculo II	4	1	4

Tercer Semestre		HC	HL	CR
FS-301	Física II	4	0	4
MA-401	Cálculo III	4	1	4
IM-101	Gráfica	2	4	3
EG-4	Repertorio	4	0	4
FS-302	Lab. Física I	0	2	1.5
LM-1003	Inglés Básico(2)	3	0	0

Cuarto Semestre		HC	HL	CR
FS-401	Física III	4	0	4
MA-501	Ecuac. Dif.	4	1	4
IM-313	Termodin.I (1)	3	0	3
IM-207	Mecánica I	3	0	3
FS-402	Lab.Física II	0	2	1.5
LM-1004	Inglés Básico	3	0	0

NOTAS:

(1) Para ingeniería eléctrica se coloca en este lugar IE-209 Circuitos I y se pasa más adelante la TErmodinámica.

(2) Estos cursos no son obligatorios pero pueden tomarse si son necesarios para cumplir con lo establecido en el Reglamento. Véase párrafo 21, Examen de Inglés.

PROGRAMA MODELO INGENIERIA INDUSTRIAL

Quinto Semestre		CL	LB	CR
EG-6	Repertorio	4	0	4
IM-307	Mecánica II	3	0	3
IM-308	Lab. Mecán. I	1	4	3
II-305	Prob. y Estad. I	3	0	3
II-301	Contabilidad	3	0	3
II-200	Fund. de Ing. Ind.	2	0	2

Sexto Semestre		CL	LB
IE-217	Prog. Mét. Num.	2	2
IE-305	Mat. Sup. para Ing. Indust.	3	0
II-421	Anál. Económico	3	0
II-405	Prob. Est. II	3	0
II-415	Metodos y Medic.	2	2
IE-203	Ing. Eléctrica	3	0

Sétimo Semestre		CL	LB	CR
II-317	Utiliz. de Calc.	2	2	3
II-403	Invest. de Operac.	3	0	3
IM-451	Procesos de Manuf.	2	4	4
II-409	Diseño Procesos	3	0	3
IM-315	Mec. del Sólido	3	0	3
	Electiva I	3	0	3

Octavo Semestre		CL	LB
II-410	Proyecto	0	6
II-407	Control Operac.	3	0
II-411	Administración	3	0
II-400	Seminario	2	0
	Electiva II	3	0

MATERIAS ELECTIVAS
EJEMPLOS DE SECUENCIAS

II-413	Contrat. y Espec.	3	0	3	IE-209	Circ. Lineales	3	2
II-417	Psicología Ind.	3	0	3	IE-409	Sistemas	3	0
IM-423	Mecánica Fluídos	3	0	3				
IM-327	Transf. de Calor	3	0	3				

También se pueden tomar como secuencias electivas dos cursos de la Escuela de Ciencias Económicas con la aprobación del profesor guía

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